JOURNAL

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OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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AN IMPERATIVE NEED

THERE CAN BE NO DOUBT THAT THE CONTINUED prosperity of the United Kingdom depends, more than ever before, upon the continued supply of adequate numbers of professional engineers. A very large proportion of our export trade is directly dependent upon the engineering industry, and professional engineers are required in considerable numbers in other branches of industry which are also contributing to the maintenance of our exports. There is also the apparently insatiable demand for both engineers and physicists by Government-controlled research establishments. The demand for professional engineers in both manufacturing and the operating side of industry continues to grow at a rate which, unfortunately, is not matched by the output of our universities and technical colleges.

It would, of course, be a fatal mistake to assume that a mere increase in numbers would be of any lasting value. It is essential that a young man entering the profession of engineering should be well educated in the widest sense of the term and well equipped technically to meet the ever-increasing demands which are being made upon the profession. No alleviation in standards of entry to the profession is to be expected therefore. Indeed it is in the best interests of those embarking on an engineering career that the standards of entry should be constantly under review, in order to ensure that in later years they may feel no lack of confidence or competence in facing up to their responsibilities, and the extensive changes in the Institution Examination Regulations made 18 months ago were originated with this end in view.

In a nation such as ours there can be only a limited number of people with the necessary inherent ability to attain professional status, and of these only a proportion will be sufficiently scientifically minded to be interested in engineering, or competent to become engineers.

The difficulty remains, however, that more recruits—to electrical engineering, particularly—must be found if we are to continue to hold our own among the industrial nations of the world. Some considerable time and attention have already been devoted to this problem by members of Council and of the Education and Training Committee; they would be the first to agree that much more must be done in the future. Approaches have been made to public schools with the object of persuading more young men, including some of those who have specialized in such subjects as classics and history, that the profession of engineering offers unique interest and opportunity, and further approaches are planned to grammar schools. It is evident that one of the major difficulties is the serious shortage of science teachers, and this problem must be faced on a national basis if the supply of professional engineers is to be maintained at its present level, let alone increased.

Meanwhile, every member of The Institution is urged to exercise to the full any private or official influence that he can bring to bear to ensure that boys are fully informed of the opportunities that are afforded within the profession. Most young men are willing, if not anxious, to contribute something to the common weal. The engineering profession offers a most excellent opportunity of doing so through the medium of an intensely interesting career.

The Council are actively preparing plans which, it is hoped, will result in focusing more attention by schools, parents and boys, on the possibilities of the profession, but these efforts are likely to be of little avail unless members accept their own responsibilities in this matter.

It is often suggested that the status of the profession and of the professional engineer is not sufficiently appreciated publicly and that this affects our recruitment seriously. Future issues of the *Journal* will probably be having something to say on this subject; it is perhaps important to remind ourselves that our public recognition will depend largely upon our own individual and collective attitude of mind to the problems which affect the profession. If we are justly proud of our professional heritage, and moreover are prepared to demonstrate our pride, young men will soon realize that fact and will wish to become associated with us in ever-increasing numbers.

Journal I.E.E., February 1955

MEASUREMENT AS A FACTOR IN UNDERSTANDING

K. J. R. Wilkinson, D.Sc., *Member*

This article is based on the Measurements Section Annual Lecture which was delivered by Dr. Wilkinson on the 11th May, 1954.

THE whole range of scientific interest, extending from nuclear to stellar events and from physical objects to intelligence quotients, is supported essentially by measurements. Yet measuring processes are so natural an activity that we normally ignore their underlying significance; when looking at a clock or a planimeter or making any other measurement we are concerned with the reading, and seldom have cause to reflect upon the mechanisms which give that reading.

Measurement implies the isolation of agents or forces in their act of responding to some natural law, and even on the best chance our perception of the fundamental mechanisms underlying any measurement is likely to be fleeting. But if, through its interpretation of a piece of science, the measurement does make a conscious impact, it then contributes substantially to our understanding, and it is this aspect of measurement, its ability to turn a vague formal doctrine into something having imaginative significance, that I shall discuss.

Concepts

Our ideas of physical quality, or dimensions, can be taken for granted when dealing with tangibles like length, force and temperature; but in those fields of engineering interest which lie outside the five senses, ideas have little contact with common experience and are correspondingly more imaginative. Yet our ideas of something as highly imaginative as inductance, for example, are far from personal, because the mind acquires these concepts in a very formal way. The engineer will obediently think of inductance as a circuit impedance, pictured like a helical spring and associated with the symbols $L\omega$ or $L(d/dt)$. Indeed this view need be questioned only if he is faced with an unorthodox example of it—perhaps the inductance offered by some complex earth-return path, which only a strong imagination could possibly coil into a spring.

Of course, the mathematician and the physicist also undergo formal courses of study, but theirs have each a different emphasis and outlook. For example, if a distribution transformer is examined, the mathematician must regard it as a collection of field problems made quite intractable by the appalling choice of boundary conditions, and the physicist will be aware of it as a severely practical manifestation of many electromagnetic phenomena; only the engineer will see it in relation to the system in which it is to work, and assess the economics of its manufacture, its efficiency, its reliability, and the life expected of it.

The Engineer's Outlook

The engineer's professional regard for science is that it shall be exploited as effectively as possible. He is therefore less occupied with the changing philosophical problems thrown up by discoveries in the field of physics, and the more ready to simplify, discarding lower-order effects, in the hope of achieving some workable basis for his thought. Indeed, he may seek to distinguish factors by labelling some of them "cause" and others "effect" where the physicist would consider the labelling irrelevant if not illogical. In the engineer's concern to exploit natural phenomena, if it helps him to think of stress as the cause and strain the effect in one place, and just the reverse in another; or that the flux density called B is caused by a quite different sort of influence known as H; or that the poles of an electromagnet present surfaces at different magnetic potentials; then he cheerfully does so and modestly accepts any charge of inconsistency as a tribute to his versatility and breadth of outlook! The success of the practising engineer does not depend upon his adherence to any one dogma, but upon the assurance with which he can foretell the outcome of some complex undertaking with nothing but a mother wit and faith in his knowledge of engineering science to guide him.

The word "faith" is used here to convey the attitude of the engineer towards his accumulated stock of knowledge; so it will depend not only on that knowledge, and on his experience of it, but also on the form of his education and on his own nature. It is therefore a far-from-uniform and not at all a logical factor, for faith is not a reliable index to knowledge. (Indeed, when it is being most effective, faith is probably at a minimum; as when a serious doubt prompts active inquiry into the validity of a particular piece of knowledge.) In engineering this faith is acquired so naturally by the application of one's knowledge that it tends to become identified with experience, or even with intuition. But this personal quality, which is essential in any creative development, extends beyond these and involves a conviction stronger than is carried by an untried intuition; it represents a man's critical attitude to his knowledge and must often transcend his experience; it is an attitude we shall call *understanding*.

Understanding

It is a natural mistake to identify an understanding of some branch of engineering science *with* that science, and the longer this understanding has been established, the less personal and more objective does it seem to become; soon it masquerades as fact. Yet it is a personal and subjective quality and can be as unrelated to fact as the flat-earth theory; or as a statement in a radio commentary I heard about a year ago, which said that because it takes eight minutes for light to reach us from the sun, the sun's position is about a diameter ahead of where we see it.

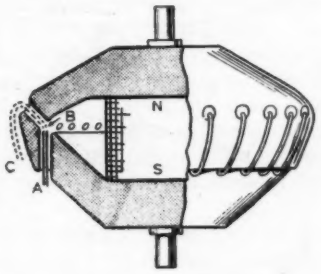
That understanding may entertain a fallacy in some absolute sense must always be acceptable as possible, as these examples show, but the significant point is that it appears to its possessor to be valid, and to be successful when applied to his problems. If understanding were usefully effective only when free from all error and rigorously true, scientific progress and engineering achievement would both be impossible. Nor is it necessary that understanding shall be clear: a boy in the fourth form has a much clearer understanding of radio, or interplanetary flight, or gas turbines, than he will come to have later on, when his critical faculty is more strongly developed.

In electrical science, now a mature established doctrine, the student is sheltered by the teaching body from all but the most orthodox thoughts. (So well that he will soon be denied the instructive C.G.S. systems on the ground that they may confuse him; even the simple 4π becomes tendentious.) But though it starts from a formal instruction, the engineer's understanding is the result of experiment: the mental experiment (as his understanding matures) of asking himself what Nature would do if confronted by a certain set of conditions, but mostly the physical experiment of asking Nature critical questions and interpreting her answers through measurements.

Let us now look at examples of how such measurements can affect understanding. For the most part these examples will be elementary in the sense that the measurements are intended to give simple answers.

The Multi-turn Homopolar Generator

Fig. 1 shows a machine made up by an engineer after reading Professor Cramp's paper on the mysterious nature of motional e.m.f. The idea is a simple one; a conductor AB rotating in a magnetic field can be held to experience an e.m.f. Authorities have said that the question whether a circularly symmetrical field of this sort rotates or is stationary when its magnet rotates is meaningless, and so let the assembly of permanent magnet and poles all rotate, together with the conductor. If the conductor AB is now extended to C through a tunnel in the steel pole, that should serve both to protect the portion BC from flux and to complete a turn. In principle, more turns can now be added to form a winding, and the result would appear to be a multi-turn homopolar generator—a very desirable invention. Of course there are excellent arguments and even a theorem to say that such a generator cannot work, but it is not easy to see where the reasoning in favour of it working breaks down, and so hope in the device remained until, when it was completed, the critical question was answered experimentally. A very sensitive galvanometer showed—certainly to one part in a thousand—that the hoped-for e.m.f. could not be found when the device was spun. No enthusiasm can stand a rebuff of that sort, and the result of this simple measurement was a salutary addition to the engineer's understanding. The interesting point is that until this simple and effective measurement



1 *Illustrating a homopolar fallacy*

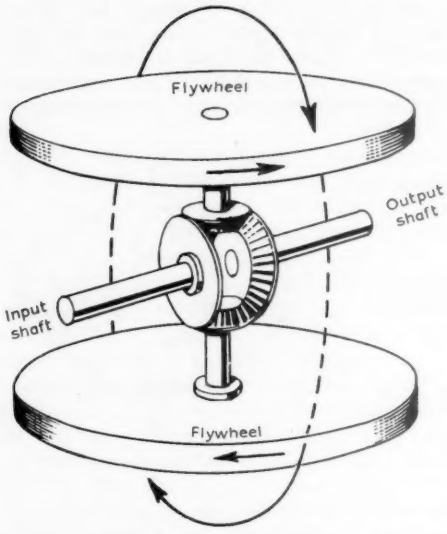
was made, a mental comprehension of the fallacy was not achieved, because any consideration admitting a fallacy would destroy interest in the measurement. To comprehend an abstruse counter-argument one must first be convinced the argument is worth comprehension. In this machine there is no e.m.f., basically because no conductor is in motion relative to the elementary dipoles which constitute the magnetic material.

The Variable-Speed Gear

An interesting discussion recently occurred about the invention for a variable-speed gear which is illustrated in Fig. 2. The idea is that a torque will be transmitted from the input to the output shaft, but in inverse relation to the speeds of the shafts, the torque difference serving to overcome gyroscopic forces in the plane normal to the two shafts. An engineer who was consulted said the invention was misconceived, for gyroscopic torques were not present in that plane. A physicist present said he thought it *would* work. Then it was learnt that the inventor had demonstrated that a torque *was* transmitted. The engineer's understanding, alert to join any interesting cause and mesmerized by this last statement, now went to work and produced a plausible analysis to show that the invention should indeed work. Meanwhile the physicist had consulted his mathematics and said it could *not* work; this shock allowed a belated and important question to be asked—how big, and in what direction, was the transmitted torque? The answers turned out to be that the torque was in the direction opposite to that required by the plausible analysis, and was due simply to friction.

Here was a case, then, where a wrong preconception

flourished because measurement was treated superficially. We can assert that, whatever other relationships may exist between understanding and measurement, unless the measurement is desired as important evidence, to be considered critically and compared with predicted ideas,



2 *An idea for a variable-speed drive*

it is most unlikely to have a profitable bearing on understanding.

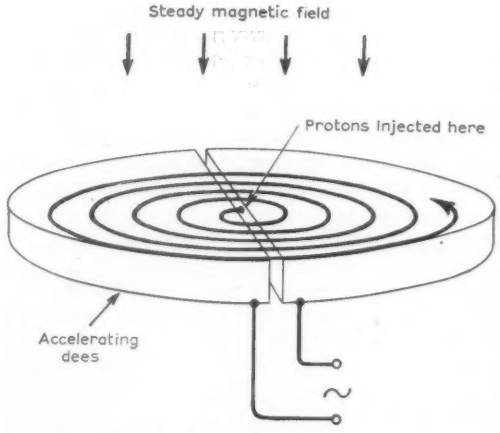
Electricity

Understanding is complete when measurement confirms a plausible theory, but where measurements have no theories to account for them, understanding remains partial and curiosity is unsatisfied. No acceptable theories can yet account for the presence either of the earth's magnetic field or of the earth's atmospheric electric field (of about 300kV positive between the ionosphere and ground). In a world where knowledge is apparently so complete this glimpse of the inexplicable is unusual—even uncomfortable—in so elementary a form. Yet in some ways it compares with our rather restricted view, as engineers, of electricity itself. Thus current is usually thought of as a vague but essentially fluid agent accompanied by two quite distinct and separate phenomena—magnetic and electric fields. This is because we seldom have to think of the very stuff of electricity—the elementary charged particles which by their motion give rise both to magnetism and electricity. However, the wider view becomes insistent when high-energy particle accelerators are considered.

Particle Accelerators

In the cyclotron, first conceived by Professor E. O. Lawrence in 1930, protons are accelerated by causing them to trace out an expanding spiral. Half the spiral is within one dee-shaped container (Fig. 3) and half within the other. At right angles to the plane of the spiral there is a steady magnetic field, and so, once launched from a gun near the middle, the particles rotate because of this field. Each time they pass out of one "dee" into the other, they experience an accelerating electric field, obtained by feeding the dees with r.f. voltage, alternating at the frequency* of rotation. In this way protons may achieve energies equivalent to a fall through millions of volts. Yet there is nowhere a voltage of this magnitude; the proton's charge is substantially unaltered, and so the energy is purely kinetic in form; in principle it could have been gained in a gravitational† field. I shall return to this point.

The notion that charged particles could be accelerated if they circled a changing magnetic field was first discussed in relation to astrophysics, in 1933; then in 1940 Professor Kerst demonstrated the successful operation of a betatron. Fig. 4 shows the principle of it; if electrons are travelling in a circle which links a changing accelerating flux they gain energy with each rotation. To keep them in a circular orbit it is necessary that the guide flux (which balances centrifugal force) shall vary in proportion to the accelerating flux, and this is easily contrived. However, there are many difficult secondary problems to be solved, and I shall not easily forget the very moving experience in 1947 of seeing evidence for the first time that electrons had been safely accelerated to 10MeV while travelling in a narrow glass tube for a distance



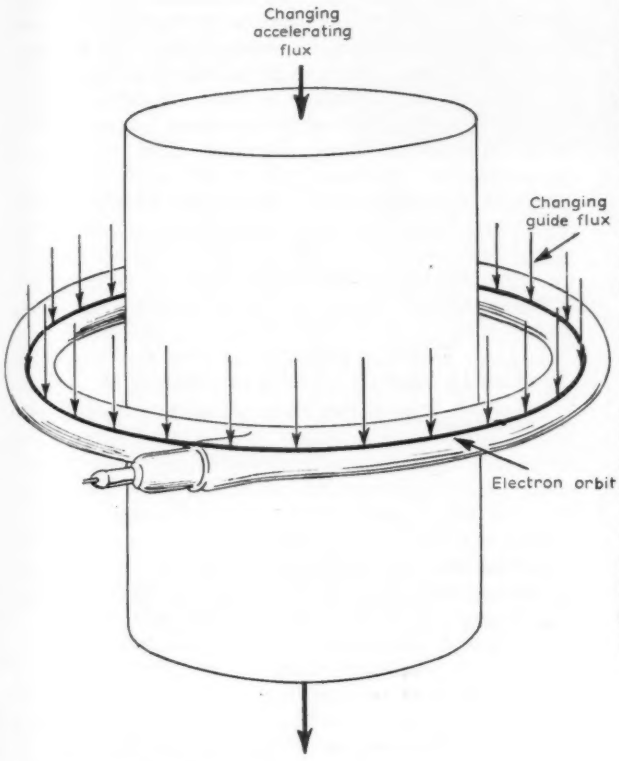
3 *The principle of the cyclotron*

equal to 900 miles. That first response of the Geiger tube, showing the presence of high-energy electrons after months of arduous and fruitless endeavour, contributed

* This frequency, conveniently, is constant until energies become very high indeed, for as the velocities increase so does the radius of rotation.

† But if the proton fell freely through a kilometre on this planet, gravitation is so slight that it would acquire energy equivalent to only 100 μV.

most profoundly to my understanding of the mechanism whereby the electrons are accelerated. By "understanding" here I mean faith in the knowledge that the electrons *are* accelerated, while recognizing that the electric field due to changing flux—the field which accelerates them—closes on itself. The electron cannot then be said to fall through so many "volts" in each turn, because there can be no voltage difference between points in a symmetrical closed field of this sort. In accepting this we must find that the concept of voltage—or potential—has no longer the physical significance usually assumed for it; it becomes a convenient but abstract product of integration. Perhaps this sounds like heresy, but we must remember that the voltage between the terminals of a transformer winding, or an inductor, can have quite different values depending upon whether the path considered lies in the air, or in the copper. Voltage is ambiguous, an electric field is not.

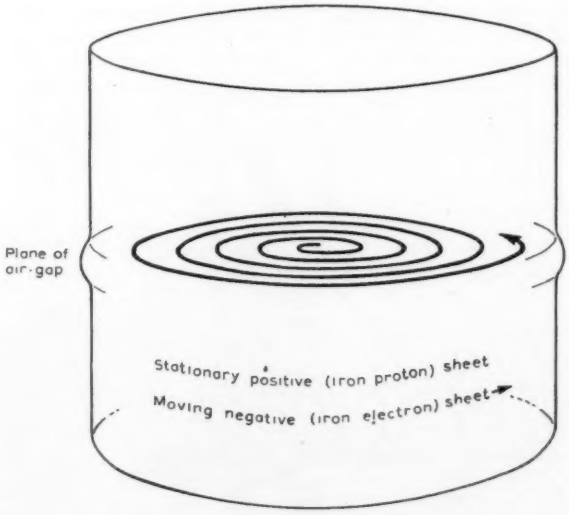


4 *The principle of the betatron*

Magnetism

Those measurements which established the operation of a cyclotron or a betatron are also important in illustrating the nature of magnetism. We accept without question the doctrine that a current in a magnetic field experiences a force, but somehow force on an isolated particle moving in a magnetic field calls for a second thought. One observer may say that a moving particle carries a magnetic halo and this must give it some title to experience a force. But how can the particle know it carries its own magnetic field? Others may say that motion endows the property of transforming magnetic and electric fields. This is a simple statement, but somehow unsatisfying, suggesting a hidden connection between two very dissimilar fields. The connection is indeed a very basic one; it rests simply in the universally accepted idea that relative motion conveys a Fitzgerald–Lorentz contraction in the direction of that motion. To take an example, particles in the dees in the vacuum space between the iron poles of a cyclotron magnet (Fig. 5) perceive, not a magnetic field, but simply those few electrons in the iron atoms which have unpaired spins, together with a corresponding number of protons. (All other electrons and protons in the iron cancel each other's effects.)

On a macroscopic scale unpaired electron spins of the atoms of the excited magnet steel will resemble a moving sheet of electrons—or current—which surrounds the magnet poles and gap alike, as a sort of solenoid. To charged particles stationary in one of the dees there would, of course, be no preponderance of charge, for they would see just as many electrons as protons in the iron, but as soon as the accelerating particles move, the Fitzgerald–Lorentz contraction ensures that they find electrons more crowded than protons on one side of their path, and less crowded on the other side. In other words,



5 *An electrical interpretation of "magnetism" as applied to the cyclotron*

In its excited state the magnet looks like a sheet of moving (iron atom) electrons. The iron atom's protons are stationary.

the particles experience an electric field at right angles to their motion, and so follow the circular path we ascribe to magnetic forces; if particles in space perceive only electric forces, so must electrons in conductors.

On this view, then, we can say that magnetism need not be a basic concept, but merely a manifestation of charge in motion. Yet if it had not been regarded, right from the first use of lodestone, as an influence in its own right, there is no doubt whatever that mathematicians would have invented such a concept because of its extreme usefulness in handling electrical problems. However, in groping for knowledge the mind is concerned, not with convenience, but with an attempt to get nearer to ultimate reality, and free from any formal doctrine which may fail to carry conviction.

Conclusion

In weighing man's understanding of the physical sciences it is evident that complete knowledge is most elusive. Yet the engineer is nothing if not persistent, and if true knowledge is hard to come by, he will adopt a working substitute; by devoting mental effort he will apply to it a faith so that it becomes his understanding. In some remarkable way, to achieve understanding is only partly an act of volition. Professor Polanyi* has said that pioneering in science is not simply the adoption of one hypothesis after another, as each in turn is proved wrong, but the arduous following, in spite of setbacks, of some blind intuitive faith. Mostly the effort is fruitless, sustained by a fascination which accepts defeat after defeat; vague shapes of the truth take on outlines of certainty, only to dissolve again. The pending scientific discovery seems to be an emergence guided by an aspect of nature that is seeking realization in the scientist's mind, a sort of extra-sensory perception but something demanding an extended effort of mental concentration. Professor Polanyi was speaking of the physicist or chemist who is creating new knowledge, but we all have some awareness, I think, of what he describes.

In conclusion, I should like to express my indebtedness to others for many helpful discussions of these eternal verities—notably Mr. C. H. Collie, Professor R. Peierls, and Professor C. J. Milner. I am also most grateful to Mr. L. J. Davies, Director of Research, the British Thomson-Houston Co., for his encouragement.

* POLANYI, M.: "Science, Faith and Society," Riddell Memorial Lectures (Durham University, 1946).

Wind Energy

by

E. W. GOLDING, M.Sc.Tech., *Member*

A PAPER BY MR. GOLDING ENTITLED "ELECTRICAL ENERGY FROM THE WIND" WILL BE READ BEFORE THE INSTITUTION ON THE 31ST MARCH.

Old-fashioned corn-grinding windmill, Bogø, Denmark

THE windmill was one of the earliest devices used by civilized man for the exploitation of natural resources of energy to supplement his inadequate supplies of man- or animal-power. Though perhaps not quite so old as the water wheel, it appears to have been in use for at least 2 000 years and was a very important power producer for corn grinding and water pumping until the end of the last century. Then the steam engine and electric motor replaced it for the larger power plants demanded by the reorganized flour-milling industry, dealing with vast quantities of imported wheat, and for more ambitious drainage schemes.

The unreliability of the wind as a power source, the limitations imposed on the location of windmills, and the decline in the craft of the millwright as other prime movers, more suited to modern industry, gained in popularity, led to the windmills being abandoned to such a degree that only dozens now remain in operation in European countries where thousands were turning but a few decades ago.

The old mills, which, as well as being picturesque, were indeed beautiful pieces of work, produced some 30 or 40 h.p. in a good wind and served their purpose nobly for centuries, but inevitably they became outmoded.

F. L. Smidth (50kW) and Lykkegaard (30kW) windmill generators near Ullerslev, Fünen, Denmark

They were succeeded by water-pumping windmills of the multi-bladed-wheel type, on which large areas in some dry parts of the world have long been dependent for their water supply, and by many thousands of small wind-driven electric generators, with propeller-type rotors, affording electric light to dwellings in remote districts. But only in Denmark has there been continuous progress in the development and use of larger windmill generators (up to 70kW) to ease the difficulty of power generation in a country with sparse indigenous energy resources. Since the Second World War, however, there has arisen a keen and very widespread realization of the possibilities of wind power; some 30 to 40 countries are actively interested in the subject, and a number of them have established officially sponsored wind-power committees to control appropriate investigations.

It is natural to ask why this is so.

The answer lies partly in the increasing cost of power generation from fuels and in the realization of the speed with which world supplies of these are being exhausted; partly in the desire of countries lacking fuels of their own to be independent of imports; partly in the need to use local energy resources, such as wind or solar radiation, to develop, for food production, areas which are at present uncultivated; and partly in the greatly increased knowledge of aerodynamics resulting from the rapid advances in the aircraft industry.

Consideration of the potentialities of wind power leads to a conception of three well-defined scales of utilization for different purposes. These are: (*a*) small scale, using machines of capacity up to 10kW for electricity supplies, or for water pumping, at remote individual premises; (*b*) medium scale, with machines of 10–100kW, to provide the energy needs of isolated communities; and (*c*) large-scale, in which wind-driven a.c. generators, of capacity 100kW upwards to perhaps 2 000kW or 3 000kW, feed their output directly into main electricity supply networks.

There are, of course, problems to be faced in developing the economic utilization of wind power under present-day conditions. These problems arise from the low density of air, which necessitates the use of large volumes for a significant amount of energy to be extracted from winds of average speed; from the fickleness of the wind, which means that, although the annual total of energy available is dependable, a supply of power at any given time is not—unless expensive methods of storage are resorted to; and from the fact that wind-driven machines for installation in remote and exposed places must be robustly constructed to withstand gales and must demand the minimum of maintenance by skilled workers. In addition to solving such problems, the designer must take into account the wind régime at the site so that the machine shall be constructed to operate over the optimum range of wind speeds.

Mynydd Anelog, Caernarvonshire—a good wind-power site

For the potential user, also, there are the problems of finding favourable sites and of devising methods of using the machines so that full advantage shall be taken of all the energy becoming available at random times, without incurring heavy costs for energy storage to maintain a power supply during calm spells.

Without doubt there is ample energy in the wind to meet the needs of scattered communities, in many parts of the world, which cannot be given power supplies from more conventional sources. To do this economically should certainly be possible, and its accomplishment presents a challenge both to the designer and to the user.

100kW wind-driven a.c. generator, on Costa Hill, Orkney

In Britain investigations on wind-power utilization have been undertaken by the Electrical Research Association with support from the Ministries of Fuel and Power (for large-scale use) and of Agriculture and Fisheries (for small- or medium-scale use) and with the co-operation of the electricity supply authorities and manufacturers.

The cost of wind-generated energy depends upon the windiness of the site, which governs the annual output per kilowatt installed, and upon the annual charges per kilowatt for interest, depreciation and maintenance, which are proportional to the capital cost of the plant. To judge the economy of using this energy its cost must be compared with that of power generation by alternative sources. This is very important. One can base a decision on what capital cost can be justified, for a machine designed to operate in a given wind régime, only on a knowledge of this alternative cost. An annual average wind speed of 25m.p.h. and a capital cost of around £50 per kW may be required where generating costs are low, but 15m.p.h. and £150 per kW, or even more, may be satisfactory when the machine is in competition only with expensive means of power generation.

The E.R.A. researches have thus included a widespread survey to discover especially windy sites, studies of wind behaviour to determine data for the designer, design and costing studies to decide on the best form of construction, tests of the performance of machines of different types and sizes, and investigations of the best methods of loading small- or medium-sized machines to given optimum utilization of the energy they generate.

The results obtained have been encouraging. For large-scale installations many sites have been found with wind régimes capable of providing annual outputs exceeding 4 000kWh per kW through plant of potentially economic design; valuable data on gusts and on wind structure have been obtained, and performance tests on small- and medium-sized machines have indicated their usefulness for electricity supply to isolated farms and communities. Two 100kW pilot plants have been built and installed in connection with main networks. These are being tested to provide information for the next larger stage of construction. It is already clear that wind-power plants in the medium range of size, for which the scope is very large and widespread, can be manufactured at a cost low enough for them to compete favourably with Diesel generation. No definite statement on the eventual costs of large installations can yet be made, although there is no reason to conclude that these will be uneconomically high.

New wind-driven machines for electricity generation are likely to be of the horizontal-axis type, with a rotor in the form of a 2- or 3-bladed propeller, but there is some freedom of choice in the design of the supporting tower, in the method of power transmission from the rotor to the generator and in the mechanical and electrical control gear.

In spite of the considerable efforts which are being made, the total expenditure on wind-power development is still small in comparison with that devoted to some other new methods of power production. There are, however, good prospects of an adequate return on money invested in research on this subject, and groups of workers, both in Great Britain and abroad, are tackling the problems of plant construction and of energy utilization enthusiastically in an endeavour to enable wind power, in combination with other power sources, to play a useful part in future development.

LA CONFÉRENCE MONDIALE DE L'ÉNERGIE

by **Sir Vincent Z. de Ferranti, M.C., Past-President**

Sir Vincent de Ferranti, who is the Chairman of the International Executive Council and of the British National Committee of the World Power Conference, gives here some personal impressions of his visit to Brazil in July and August, 1954, for the purpose of attending the Sectional Meeting of the World Power Conference.

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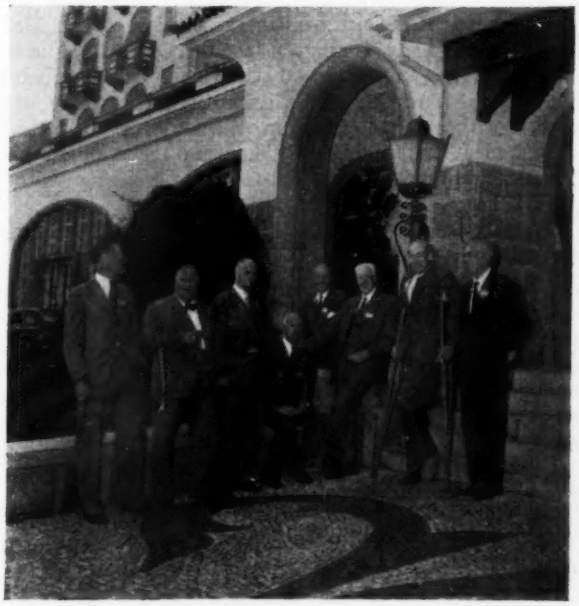
The World Power Conference (W.P.C.) has held four plenary and 10 sectional meetings since its foundation in 1924. All its pre-war meetings were in highly industrialized countries. Of the four meetings held since the Second World War, two have taken place in so-called "under-developed" countries—India and Brazil, while, after a plenary meeting in Vienna, the next sectional meeting will be held in another "under-developed" country—Yugoslavia. As an electrical engineer, I would not for a moment suggest that there is any country, not excluding the United States, which is not "under-developed" electrically. Still, it cannot be denied that some countries are less electrically developed than others, and that India, Brazil and Yugoslavia all fall into the less-developed category. So the W.P.C. can claim that it has since 1945 made it its practice to hold approximately alternate meetings in countries which offer unusual opportunities for rapid industrialization through electrification. Brazil's national plan for electrification covers a decade during which the population is expected to increase from 56 000 000 to 73 000 000. During this decade, it is hoped to bring installed generating capacity from $2{\cdot}8 \times 10^6$ to $8{\cdot}5 \times 10^6$ kW at a cost of about £220 000 000 at the present free rate of exchange.

The Brazilian Sectional Meeting of the W.P.C. originated in an invitation conveyed to the International Executive Council at a meeting held at Paris in the summer of 1951. This invitation was brought to us by representatives of the Government of Brazil and of the Brazilian National Committee of the W.P.C. The latter represents in its composition the major interests responsible for the electrification of the country. The Chairman, Dr. A. J. Alves de Souza, is the President of the Companhia Hidro-Elétrica do São Francisco, which is a State-run company engaged on developing electrically the northern part of Brazil; while the Treasurer, Dr. C. R. Farina, works for COBAST, which is the financial organization associated with the holding company known as "Brazilian Traction." Operating companies of "Brazilian Traction" and "Bond and Share" run the utilities in the great cities of Rio de Janeiro and São Paulo in the south of Brazil: not only the electricity undertakings but also the gasworks and the tramways, The Secretary of the Brazilian National Committee, Dr. Syndoro de Souza, normally works for the Government, but he established a temporary office in the COBAST building for the purpose of the Brazilian Sectional Meeting. So there was a blending of State and private enterprise.

The British members of the sectional meeting of the World Power Conference held in Brazil last July numbered about 50, including 30 from the United Kingdom and three from Africa. The remainder were Britons resident in South America, chiefly in Brazil itself. In addition, there were about 10 ladies, described in the unlovely officialese terminology as "accompanying persons." There were more participants from Britain than from any other one country, apart from Brazil itself.

There were 94 papers. Obviously, I cannot discuss these in this short article, but I can say that a high proportion were of good quality. It was interesting that, for the first time since the war, the U.S.S.R. National

1 *Lord Citrine and members of the B.E.A. and Area Board party at Quitandinha Hotel*



Committee sent their papers in advance to the National Committee of the host country and, moreover, sent them in English. At previous conferences, they have brought their papers with them and they have been in Russian.

Almost all of us stayed at the Quitandinha Hotel, Petropolis, where the meetings were also held. Petropolis is up in the hills about 35 miles from Rio de Janeiro. We were a truly international collection of guests, coming from over 30 countries; and, as always at meetings of the W.P.C., I met many old friends and made a number of new ones. I had the privilege of presiding over a meeting of the International Executive Council—the governing body of the W.P.C.—sessions of which took place at Petropolis immediately before the sectional meeting opened and immediately before its conclusion. Twenty-three of the 43 member countries of the W.P.C. were represented, consisting in almost equal numbers of delegates who had attended previous Council meetings and delegates who were attending for the first time.

We could not have been more generously entertained by our Brazilian hosts. There were receptions and entertainments too numerous to be mentioned in detail, including the traditional official banquet. But I am sure Brazilian political affairs will have a more vivid meaning for us, since the former President of the Republic, the late President Vargas, made a speech at our closing session a few weeks before his tragic death, while we also met Senhor Café Filho, who was at that time the Vice-President of the Republic and President of the Senate but has since become the President of the Republic.

I must mention the very gracious hospitality shown to us by the British Ambassador, Sir Geoffrey Thompson, and Lady Thompson. The Ambassador gave a party for all the Commonwealth members of the Conference and distinguished Brazilians. This party took place at the Embassy Residence at Rio de Janeiro. Then Sir Geoffrey and Lady Thompson lent the Embassy House at Petropolis to Lord and Lady Citrine for a party which they gave, at which Lord Citrine, in his capacity as leader of the United Kingdom delegation, received the British members, leading Brazilians, and the members of the International Executive Council, together with their ladies.

In passing, I might mention that the Ambassador showed himself very much alive to British trade possibilities in Brazil, and refused to allow himself to be discouraged by reason of the financial and economic difficulties which exist at the present time.

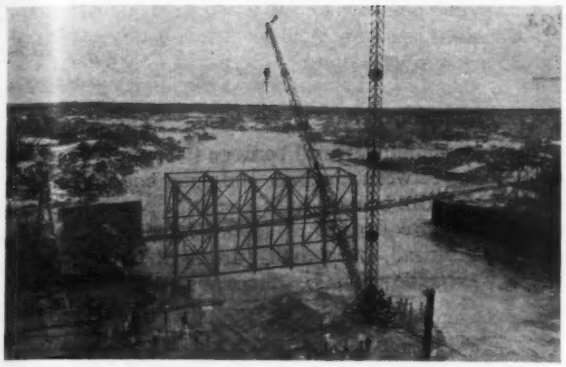
After the Conference proper was over, the great majority of the foreign participants, including almost all the British, took part in the elaborate technical tour which had been excellently organized by the Brazilian National Committee. The participants in this tour were divided into two groups, because of lack of hotel accommodation at one or two places and also because of the need to charter aircraft for part of the journey. Each group visited the same places, but in the reverse order.

On the first day of the technical tour, we travelled by road to Santa Cecília, where the dam on the Paraiba River and the diversion tunnels and canals carrying water to the underground power plant of the Rio de Janeiro Tramway, Light and Power Co. at Lajes were visited. This plant has a capacity of 330 000 kW. Then we went on to Volta Redonda, where we stayed overnight. The Brazilians are rightly proud of the iron and steel plant of the Companhia Siderúrgica Nacional, which, although it may offer nothing very novel to visitors from highly industrialized countries, is nevertheless a thoroughly up-to-date plant with a present annual output of about one million tons of steel. From Volta Redonda, we went on to São Paulo, which is the industrial capital of Brazil. Although most works of reference still show Rio de Janeiro as the largest city in Brazil, I believe the inhabitants of São Paulo claim that the population of their city has in the last few years taken the lead and now exceeds 2 700 000. São Paulo is about 2 790 feet above sea level and has a somewhat more temperate climate than Rio. Perhaps for this reason, it has attracted a large number of immigrants from northern European countries, especially Germany. It is growing faster than any other great city in the world; in fact building of all kinds is proceeding at a breath-taking speed. The impression one obtains is of a boom town: perhaps somewhat like Chicago of two or three generations ago.

While we were at São Paulo, we visited the reservoirs and hydro-electric plant of the São Paulo Light and Power Co. at Cubatão and also the new steam generating plant of the same company at Piratininga. At the latter, it was interesting to find that almost all the senior members of the operating staff are British, although the machinery is American. The explanation apparently is that the machinery has been purchased out of the proceeds of loans made by the Export-Import Bank of New York, it being laid down that American machinery must be bought. On the other hand, it has been found more economical to employ British than American engineers.

During one of our days at São Paulo, we paid a visit to the port of Santos about 25 miles away. The journey showed us one of the most remarkable pieces of road engineering I have ever seen. There are two entirely separate motor roads, one for ascending and the other for descending traffic. Our hosts proudly pointed out that this was a wholly Brazilian piece of work. It certainly shows that Latins, when transplanted into the New World, have not lost one of their traditional skills. Santos is an attractive city. From it, almost all Brazil's major export, coffee, reaches the markets of the world, and especially the North American market. It was a saddening reflection of present trade conditions to see hardly any British shipping in the fine harbour.

After three nights in São Paulo, we went by plane to the city of Salvador, in the Province of Bahia in North-Eastern Brazil. Our party filled three planes, which flew in close formation. This gave us an opportunity to admire the skill of the Brazilian pilots, although sometimes we could have wished that the formation had been a little less close.



(*a*)

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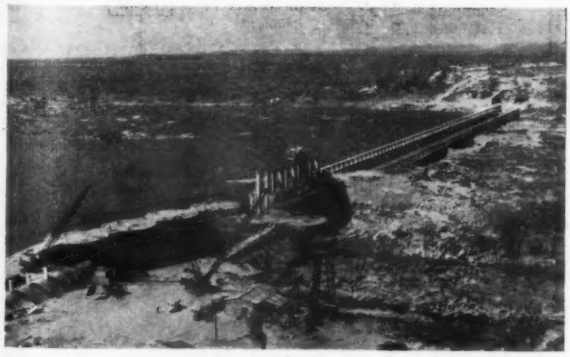


(*c*)

2 *Paulo Afonso*

(*a*) *16th June, 1954.*
The final stage of the dam construction; lowering the steel crib into the fast current to form the down-stream coffer-dam.

(*b*) *20th July, 1954.*
The steel crib filled with rock to complete the down-stream coffer-dam and provide a pool of still water to facilitate the construction of the up-stream coffer-dam.

(*c*) *28th September, 1954.*
The coffer-dam completed and pumped out ready to excavate the foundations for the final section of the dam.

Although Salvador is its official name, everybody seems to use the old name of Bahia. Bahia was the capital of Brazil when Brazil was under Portuguese rule. It has an almost perfect tropical climate, with very little difference from one month to another. There is a small daily fall of rain, between hours which can be predicted with almost complete accuracy. The heat is dry, and there is a merciful absence of insect life. In fact, while I was in Brazil the only place at which I saw mosquito nets was at Volta Redonda, and even there it proved quite unnecessary to use them.

The life in the streets of Bahia moves at a tropical tempo and the city is altogether delightful. It claims to have one church for each day of the year, but I am informed that this is rather surprisingly an understatement and that there are in fact more than 365 churches. The church of São Francisco, which was one of those that we had time to visit, is an outstanding example of baroque art.

From Bahia we made a visit to the oil wells and refinery of the Conselho Nacional do Petróleo. There was also what was perhaps the high-light of the entire tour: a whole-day visit to the hydro-electric installations of the Companhia Hidro-Elétrica do São Francisco at Paulo Afonso, which we reached by plane. Paulo Afonso lies about 300 miles north of Bahia and roughly 150 miles inland from the Atlantic coast. It is situated on the huge São Francisco River in a region which is practically rainless apart from occasional violent thunderstorms. Under normal low-water conditions the group of falls and rapids have a total drop of about 85 metres in the course of just over three miles. The first phase of the scheme, now almost completed, involved the construction of the dam and underground power station with three 60 000kW generating sets, together with transmission lines to Bahia to the south and Recife to the north-east. Eventually, it is planned to raise the total capacity to 900 000kW by the construction of four similar underground power stations.

It was a great pleasure to be received at Paulo Afonso by Dr. A. J. Alves de Souza, on this occasion in what is very much his own territory, and to listen to a most lucid exposition in English of what will eventually be the largest hydro-electric scheme in South America by Dr. O. Marcondes Ferraz, Technical Director of the Companhia Hidro-elétrica do São Francisco.

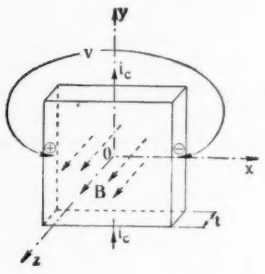
From Bahia we returned by air to Rio, where I had a few days to rest and sort out my impressions before leaving for home. Brazil is as large as the United States, with an additional area of the size of Texas thrown in. I had certainly not previously realized how immense and varied in character is this giant of South America, or what almost boundless opportunities it offers for the future. And I also took away with me a strong impression of a friendly people whose country I should much like to revisit.

Semi-Conductor Wattmeters

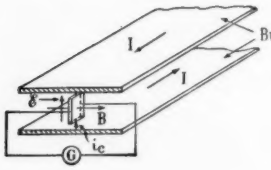
A DIGEST OF TWO MEASUREMENTS SECTION PAPERS ENTITLED "THE APPLICATION OF THE HALL EFFECT IN A SEMI-CONDUCTOR TO THE MEASUREMENT OF POWER IN AN ELECTROMAGNETIC FIELD" (No. 1654) AND "THE DESIGN OF SEMI-CONDUCTOR WATTMETERS FOR POWER-FREQUENCY AND AUDIO-FREQUENCY APPLICATIONS" (No. 1778), BY PROFESSOR H. E. M. BARLOW, PH.D., B.SC.(ENG.), MEMBER. THE FULL PAPERS WERE PUBLISHED SEPARATELY IN JUNE AND NOVEMBER, 1954, AND THEY WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

THE ADVENT OF SEMI-CONDUCTORS such as germanium, which exhibit a large Hall effect, has made possible the development of a new kind of wattmeter for the measurement of the power transmitted along a line or a hollow metal waveguide.

When a current flows through a semi-conductor at right angles to an externally applied magnetic field, as shown in Fig. 1, the current streamlines are pushed side-

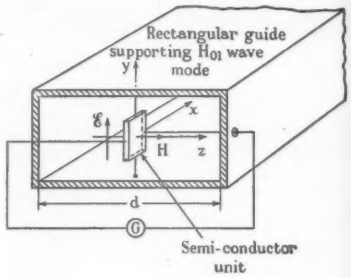


1 *Semi-conductor element*
The positive and negative signs indicate the sign of the Hall e.m.f. for mobile negative carriers.

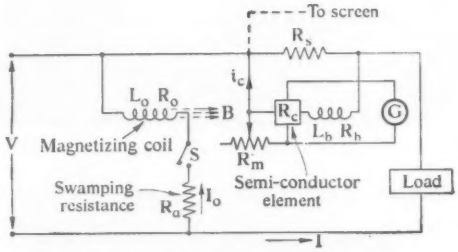


2 *Parallel-strip transmission line with semi-conductor unit mounted between the busbars*

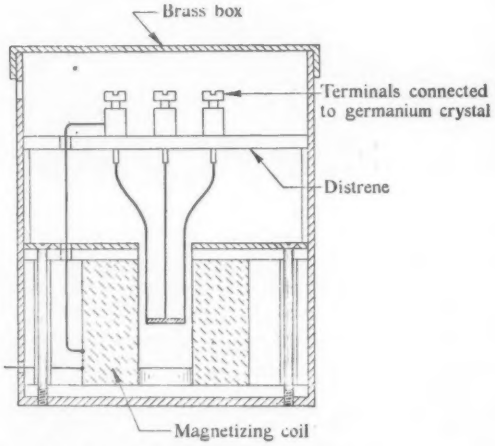
ways, giving rise to a small transverse e.m.f., v, representing what is called the Hall effect. It is shown that the instantaneous value of this Hall e.m.f. is directly proportional to the instantaneous power traversing the piece of semi-conductor, so that by associating such a device with a line or guide directing the electrical energy, the true mean value of the Hall e.m.f. can be used to give a measure of the power transmitted. Various types of wattmeter embodying this principle are described in their application to measurements over a wide range of frequencies up to the microwave band. Thus a small slice of germanium erected between two parallel busbars (Fig. 2), or between the inner and outer conductors of a coaxial line, can be used in this way for power measurement up to frequencies of several hundreds of megacycles per second, and a similar arrangement is proposed for a waveguide (Fig. 3). Since it is an advantage in



3 *Rectangular waveguide supporting an H_{01} wave mode with semi-conductor unit mounted at a point on the axis*



4 *Circuit of the semi-conductor wattmeter*
The screen is used only in the a.f. instrument.

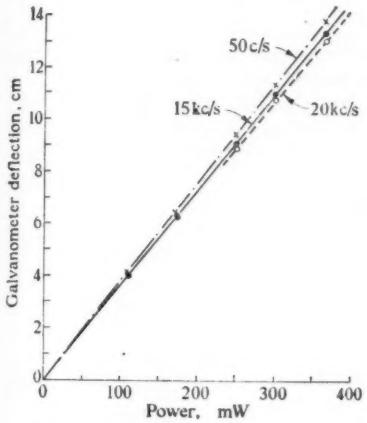


5 *An a.f. wattmeter for use up to 20kc/s*
Magnetizing-coil and crystal assembly: $L_o = 29{\cdot}8$mH and $R_o = 665$ ohms.

these instruments to make the magnetic field applied to the semi-conductor element as strong as possible, it is convenient at low frequencies to introduce a magnetizing coil with a circuit arrangement (Fig. 4) similar to the more conventional type of dynamometer wattmeter. It is important in all these applications to eliminate so far as possible rectifier effects arising from electrical asymmetry of the semi-conductor element, because these tend to produce an output at the Hall contacts in the absence of an externally applied magnetic field.

Professor Barlow gives details of the design of two typical wattmeters using germanium crystals, one instrument for operation up to 150c/s and the other covering frequencies up to 20kc/s.

The audio-frequency instrument, of which the magnetizing coil and crystal assembly is shown in Fig. 5,



6 *Characteristics of a.f. wattmeter*

includes a galvanometer amplifier for the measurement of the Hall e.m.f. and gives a scale deflection of about 2cm for a power of 50mW. The calibration curve is given in Fig. 6, and from it the error will be seen to be only 5·3% at 20kc/s.

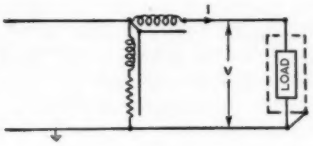
Dynamometer Wattmeters

A DIGEST OF A MEASUREMENTS SECTION PAPER (No. 1653) ENTITLED "AUDIO-FREQUENCY POWER MEASUREMENTS BY DYNAMOMETER WATTMETERS," BY A. H. M. ARNOLD, PH.D., D.ENG., ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED SEPARATELY IN APRIL, 1954, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

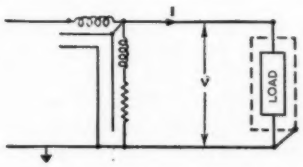
THE PROBLEM of power measurement by dynamometer wattmeters may be divided into two parts. There is first the design, construction and calibration of an instrument which will indicate accurately the quantity $f\int_0^{1/f} vidt$, where v is the instantaneous voltage applied to the voltage terminals and i is the instantaneous current through the current terminals and f is the frequency in cycles per second. Secondly there is the connection of the wattmeter into a circuit so that $f\int_0^{1/f} vidt$ accurately represents the power it is desired to measure.

At power frequencies, wattmeter design, construction and calibration may usually be considered separately from the problem of connection of a wattmeter into a circuit, but at higher frequencies the method of connection may affect the wattmeter errors.

Errors arise from electrostatic and electromagnetic coupling between circuits or between different parts of the same circuit and become increasingly serious as the frequency is raised. These errors may eventually be so serious that a dynamometer wattmeter is no longer usable. A suitable system of screening the load and the wattmeter will enable the frequency range to be greatly extended, provided that the instrument itself is suitable for these higher frequencies. A good system of screening may usually be obtained if the wattmeter is screened at the potential of one line and the load at the potential of the other line as shown in Figs. 1 and 2.



1 *Power measurement with singly-screened wattmeter*



2 *Power measurement with doubly-screened wattmeter*

This is often impracticable, however, and it may be necessary to screen both load and wattmeter at the same potential.

The internal errors of a wattmeter arise mainly from the inductance of the field coils. Some reduction of error may be achieved by capacitance compensation, but better results are obtained by the use of a feedback amplifier to maintain the correct current through the voltage circuit. It may then be possible to operate the wattmeter with negligible frequency error up to the frequency at which the error from partial resonance between the inductance and self-capacitance of the coils becomes excessive. This frequency may be as high as 20kc/s or more. The impedance of the current circuit may be reduced by the employment of a feedback amplifier, with a resultant reduction in the disturbance to the circuit in which the measurement is to be made.

Calibration of dynamometer wattmeters at the N.P.L.

is carried out by comparison with an electrostatic wattmeter. It has been established that this instrument is free from frequency or power-factor errors within the limit of 0·1% at least up to 30kc/s. Its range may be changed by the use of a voltage divider and a number of shunts. The divider must be compensated for the shunting effect of the capacitance of the electrostatic wattmeter and also for that of the electrostatic voltmeter which is used to set the voltage. The time-constants of both divider and shunts must be small and accurately known. The electrostatic wattmeter is calibrated on real load at unity power factor on one range and at any convenient frequency, not necessarily the same as that used when the dynamometer wattmeter is compared with it.

A Standard Frequency Monitor

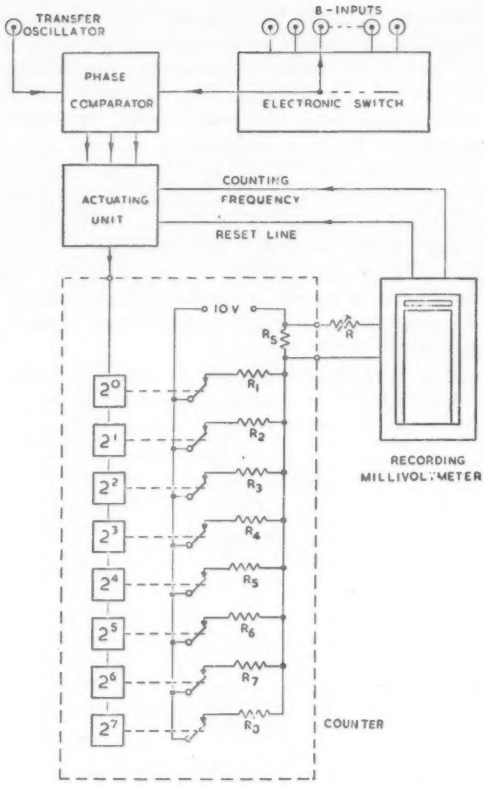
A DIGEST OF A MEASUREMENTS SECTION PAPER (No. 1765) ENTITLED "THE STANDARD FREQUENCY MONITOR AT THE NATIONAL PHYSICAL LABORATORY," BY J. McA. STEELE, B.SC.(ENG.). THE FULL PAPER WAS PUBLISHED SEPARATELY IN OCTOBER, 1954, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

THE COMPREHENSIVE FREQUENCY MONITOR established at the National Physical Laboratory comprises facilities for the automatic measurement and recording of the MSF carrier frequencies of 60kc/s, 2·5, 5 and 10Mc/s, the determination of the phase of the 1c/s pulse modulation carried by MSF and other standard frequency transmissions and, in addition, the automatic recording of the frequency of Droitwich, 200kc/s.

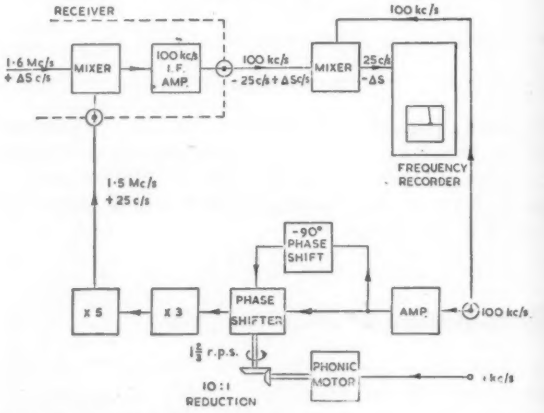
MSF 60kc/s and Droitwich 200kc/s transmissions are measured by an extension of equipment already available in the monitor for the continuous intercomparison of the N.P.L. 100kc/s standard oscillators, both these transmissions being converted to 100kc/s in their respective receivers prior to measurement. Fig. 1 shows the system of automatic recording. A phase comparator produces pulses at the beginning and end of the beat period between two 100kc/s sources. The time interval between pulses is then measured, less an integral multiple of 256, by an 8-stage binary counter. Any number held in the counter at the end of the beat is converted by a system of relays and graduated resistors into a proportionate voltage and registered on the scale of the recording millivoltmeter.

One 100kc/s standard is connected permanently to one input of the phase comparator; MSF 60kc/s, Droitwich and the rest of the 100kc/s standard oscillators are connected in turn to the other input by means of an 8-channel electronic switch. The measurement and recording of successive beat periods proceeds continuously and automatically, a complete scan of the switch occupying three minutes. The successive results are recorded by the millivoltmeter in a variety of colours.

The scale of the millivoltmeter is a time scale, but it



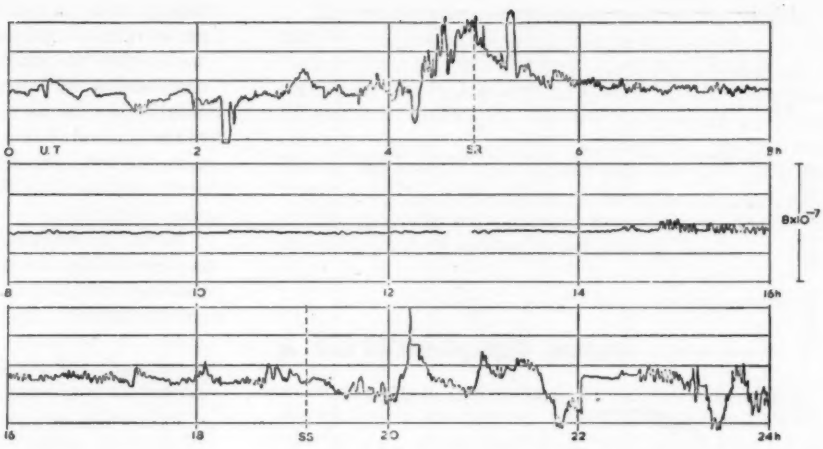
1 *System of automatic frequency comparison at 100kc/s*



2 *System of high-frequency recording*

can be regarded as direct reading in frequency difference, provided that this is suitably small. The frequency discrimination increases with length of beat and increase of counting frequency. The smallest frequency change readily detectable in normal use is about 1 part in 10^{10}.

The MSF 1c/s pulse modulation takes the form of five complete oscillations at a frequency of 1 000c/s,



3 *Received frequency variations on 2·5 Mc/s for three 8-hourly periods on 23rd August, 1953*

A deflection of the trace upwards corresponds to an increase in received frequency.

commencing with a positive half-cycle. To permit precise comparisons, a reference point is chosen in the total pulse length of 5 millisec some 200° after the commencement of the pulse. At this point a form of trigger circuit produces a short pulse which is applied to the start circuit of a decimal counter. Standard pulses at the rate of 10 per second are applied to the stop circuit of the counter, and thus what is measured is the delay of standard on received pulse. The pulse unit was designed primarily for use with MSF 60 kc/s transmission, whose reception is very stable and permits precise measurement of phase. Comparisons are confined to the last minute of each 5-min modulation period, and the total scatter of the 60 or so readings does not usually exceed 30 microsec.

In the high-frequency section of the monitor a separate receiver is provided for each of the internationally agreed standard frequencies of 2·5, 5, 10, 15, 20 and 25 Mc/s. All received frequencies are reduced, first to 1·6 Mc/s and then to 100 kc/s, by mixing with appropriate local-oscillator frequencies derived from a single 100 kc/s standard.

The MSF transmissions on 2·5 and 5 Mc/s are received after reflection in either the E or F region of the ionosphere. Owing to fluctuations in the equivalent path of the signal, the received carrier frequency is essentially variable, and it is found convenient in the monitor to record the changes in received frequency, which at times may amount to several parts in 10^7, direct on a frequency meter. The instrument chosen is a commercial form of power-frequency recorder with a centre frequency of 25 c/s and a range of ± 1 c/s. Its use requires the beat frequency between received signal and standard to be in the region of 25 c/s; this is accomplished by the use of a continuously rotating phase-shifter. A schematic of the recording system is shown in Fig. 2.

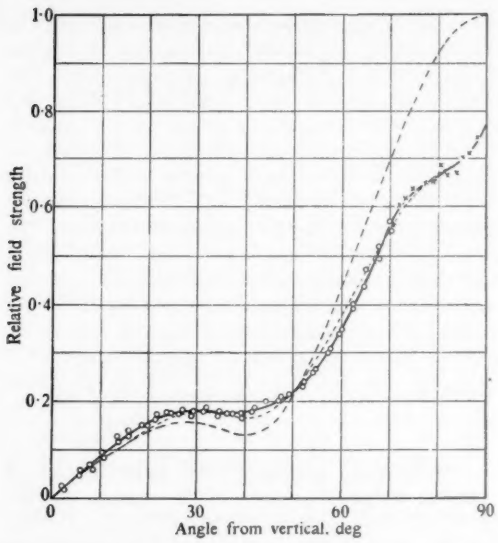
The second local-oscillator frequency of all the receivers is 1·5 Mc/s, obtained from 100 kc/s by multiplication by 3 and 5. By including a phase-shifter rotating synchronously at $1\frac{2}{3}$ rev/sec in the input to the multiplier, the multiplied frequency is increased by 25 c/s and the output frequency of the receiver thereby reduced by the same amount. Beating with the 100 kc/s standard produces 25 c/s, which is amplified and applied to the recorder.

In Fig. 3 is shown a record of the variations in the received frequency of MSF 2·5 Mc/s for a period of 24 hours. A particularly striking feature is the large increase in received frequency of some 4–5 parts in 10^7 in the sunrise period. The most stable conditions prevail from about two hours after sunrise to two hours before sunset. Thereafter, the received frequency is much disturbed, with large negative deviations.

Broadcasting Aerials

A DIGEST OF A RADIO SECTION PAPER (No. 1714) ENTITLED "THE VERTICAL RADIATION PATTERNS OF MEDIUM-WAVE BROADCASTING AERIALS," BY H. PAGE, M.SC., AND G. D. MONTEATH, B.SC., ASSOCIATE MEMBERS. THE FULL PAPER WAS PUBLISHED SEPARATELY IN SEPTEMBER, 1954, AND IT WILL BE REPUBLISHED IN PART B OF THE PROCEEDINGS.

THE SIMPLEST AERIAL used for medium-wave broadcasting is a vertical conductor carrying radio-frequency current. The energy radiated from it is generally propagated to the receiver in two ways: by the ground wave, which follows a direct path over the surface of the earth, suffering attenuation by reason of the absorption of energy in the ground, and by waves reflected at the ionosphere. At short distances the ground wave predominates, and if sufficient power is radiated a good service will result. At greater distances the reflected waves become comparable in strength with the ground wave, and selective fading, resulting in distortion of the a.f. signal, is caused by interference between them. Fading cannot be overcome by radiating more power, for this would increase sky-wave and ground-wave field strengths in the same ratio. The only remedy is to reduce radiation towards



1 *Theoretical and measured radiation patterns of a 0·55λ base-fed aerial*

———— Measured, imperfectly-conducting ground.
- - - - - - - Theoretical, imperfectly-conducting ground.
— — — — Measured, perfectly-conducting ground.

the ionosphere by controlling the vertical radiation pattern (v.r.p.) of the aerial, i.e. the pattern displaying the field strength at some fixed distance as a function of the angle to the vertical. When this has been done the aerial is often referred to as "anti fading."

The paper is concerned with the most common anti-fading aerial, a mast-radiator (a mast which itself acts as a vertical radiator) a little more than one half-wavelength in height. Its v.r.p. depends upon the distribution of current along it, for which no exact solution exists, and upon the conductivity and flatness of the ground in its vicinity. An experimental investigation into these factors was carried out by means of small-scale models (scale factor about 1/400) at a frequency of about 400 Mc/s.

Initially, v.r.p.'s were measured under conditions corresponding to a plane and perfectly conducting earth, the only unknown factor being the distribution of current on the aerial. For this purpose measurements were made on balanced dipoles, one half representing the aerial itself and the other its image in the ground. This procedure could not be used to simulate ground of finite conductivity, and so subsequent experiments were made by erecting model aerials on an imperfectly conducting surface. Since the conductivity had to be increased in proportion to the frequency, i.e. 400 times, the ground was simulated by a solution of common salt in water, contained in a concrete tank 50 ft long and 17 ft wide. A receiving aerial, supported by a pivoted wooden frame, was arranged to rotate in a vertical plane round the aerial under test, which was placed in the centre of the tank. As an example of the results obtained, Fig. 1 shows the measured v.r.p. of a typical base-fed aerial over highly conducting ground, such as would exist on a typical site in this country, compared with a theoretical v.r.p. and with a measured result for perfectly conducting ground.

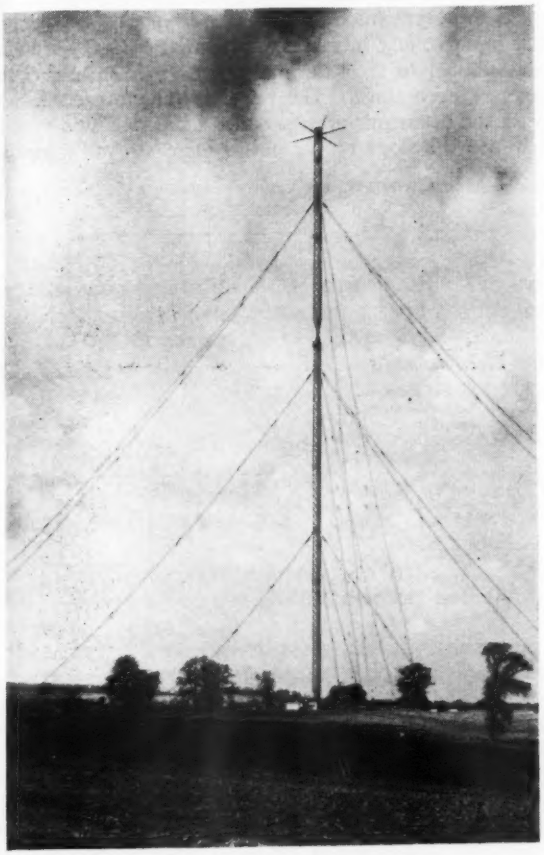
When the effect of the imperfect conductivity of flat ground had been determined, the same equipment was used to determine the effect of mounting the transmitting

2 *Measurement of the v.r.p. of a model aerial on a circular plateau*

aerial upon a hill. Fig. 2 shows the tank of brine, in which has been placed a sheet-metal model of a circular plateau supporting the aerial under test. The wooden frame carrying the receiving aerial appears as an inverted V.

The strength of the waves reflected from the ionosphere is determined, not only by the v.r.p. of the transmitting aerial, but also by the nature of ionospheric reflection. In fact, this reflection is known to be diffuse, so that the v.r.p. is, in effect, blurred. Preliminary experiments indicate that this effect is by no means negligible.

The paper concludes by giving the results of v.r.p. measurements on the Third-Programme mast-radiator at Daventry. This aerial, shown in Fig. 3, is broken by an insulator at about two-thirds of the total height, and energized at that point by means of a feeder inside the lower section of the mast. This method is termed "loop feeding." Vertical radiation patterns were measured by radiating pulses, observing the signals reflected from the ionosphere, and comparing them with similar pulses radiated from a short aerial.



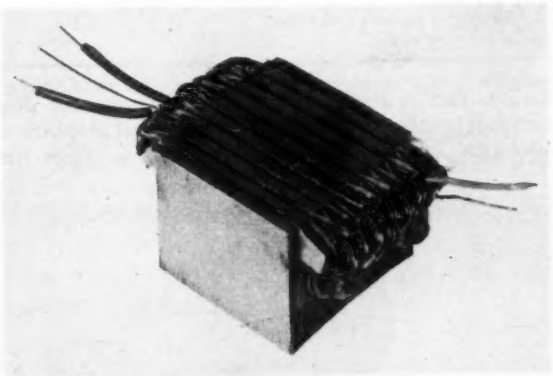
3 *Daventry Third-Programme mast-radiator*

The results given in the paper lead to the conclusion that, if the ground were flat and the ionosphere a perfect mirror, the v.r.p. and the area free from fading could be predicted with reasonable accuracy. Under these conditions loop feeding, as opposed to the more usual base feeding, would substantially increase the service area. Diffuse reflection at the ionosphere tends to restrict the improvement, but the effect of departure of the surface of the ground from flatness is more serious, apparently setting a limit to further improvement.

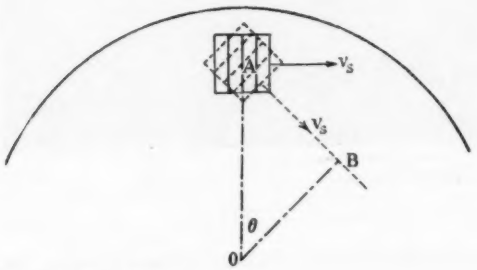
A Variable-Speed Motor

A DIGEST OF A UTILIZATION SECTION PAPER (No. 1737 ENTITLED "A BRUSHLESS VARIABLE-SPEED INDUCTION MOTOR," BY PROFESSOR F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., MEMBER, AND E. R. LAITHWAITE, M.SC., GRADUATE. THE FULL PAPER WAS PUBLISHED SEPARATELY IN NOVEMBER, 1954, AND IT WILL BE REPUBLISHED IN PART A OF THE PROCEEDINGS.

IF THE STATOR of a multi-pole induction motor is sliced through at the top and then rolled out flat, a structure such as that shown in Fig. 1 is obtained. A stator of this kind exhibits, in place of a rotating field, a moving field which travels along the stator at a speed v_s.



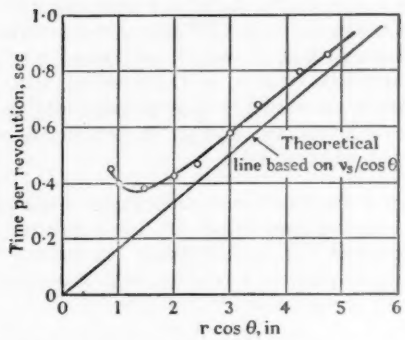
1 *Arrangement of stator*



2 *Location of stator*

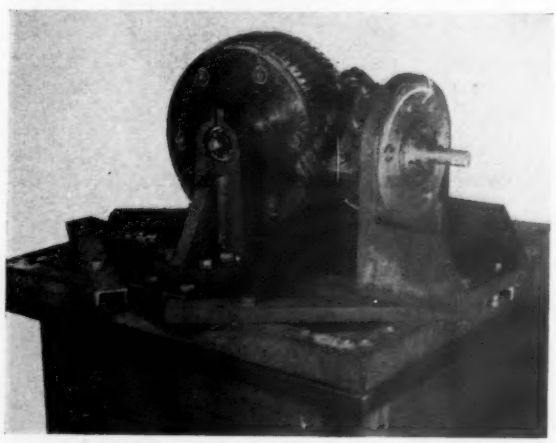
If one of these stators is placed near a copper disc, as shown by the full lines in Fig. 2, the disc rotates at an angular velocity such that the copper under the stator has a speed approaching v_s. If the stator is moved in towards the centre, it is obvious that the speed of rotation will increase. It is less obvious what will happen if the stator is rotated through an angle θ, as shown by the broken lines, so that the moving field exists still at the same radius OA, but is directed towards a point B at a smaller radius OB.

The paper is concerned with answering this question. It is found that under suitable conditions rotating the stator leads to increased speed, and speed ranges of 2·5 : 1 have been obtained, as indicated in Fig. 3.



3 *Results of initial experiment*

Various factors lead to poor efficiency with the disc machine, but the principle can also be applied to spherical machines, such as that shown in Fig. 4. Here the



4 *The spherical motor*

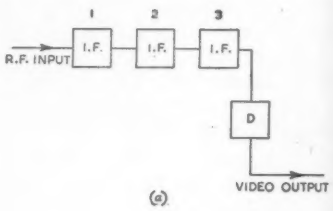
chances of achieving high efficiency are much better, and such a machine is currently being investigated.

A Logarithmic Radar Receiver

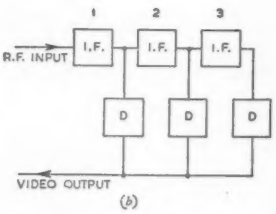
A DIGEST OF A RADIO SECTION PAPER (No. 1733) ENTITLED "DESIGN OF A LOGARITHMIC RECEIVER," BY S. ROZENSTEIN. THE FULL PAPER WAS PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

IN A RADAR SYSTEM a target appearing at the same range as clutter will not be reproduced by an ordinary receiver, owing to saturation. The logarithmic receiver eliminates saturation by using successive detection from each of its amplifying stages and adding the outputs by an appropriate delay line (Fig. 1). Any stage must provide constant output under overload conditions, so that the receiver output voltage will increase linearly (nV_{out}) while the input voltage increases exponentially ($V_{in}G^n$), n being the number of the saturated stages (Fig. 2), and G the gain of each stage. The paper is therefore concerned with the behaviour of overloaded i.f. stages.

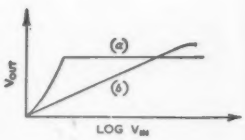
Since the slope of the pulses increases while passing

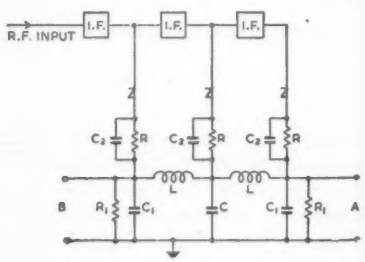


1 *Block diagrams*
(*a*) Linear receiver.
(*b*) Logarithmic receiver.



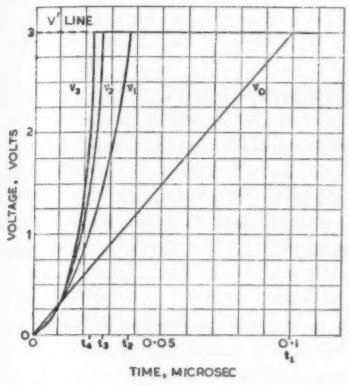
2 *Input-output relationship*
(*a*) Linear receiver.
(*b*) Logarithmic receiver.





3 *Detection arrangement and delay line*

through the receiver, the output terminals of the delay line must be at the "input end" (Fig. 3, terminals B), so that the leading edges of the video pulses will coincide, for otherwise the rise time of the total output pulse will



4 *Calculated responses of three i.f. stages to a ramp function*

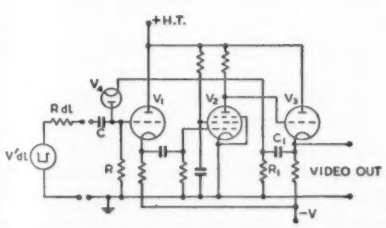
increase according to the strength of signals. This can be shown by an analysis of the response of a saturated i.f. amplifier of n stages, which gives for the output voltage $v_n(t)$:

$$v_n(t) = (-1)^n \alpha \left(\frac{g_m}{2C}\right)^n \left[\frac{t/2RC - n}{(1/2RC)^{n+1}} + \frac{1}{(n-1)!}\frac{d^{n-1}}{dp^{n-1}}\left(\frac{e^{pt}}{p^2}\right)_{p=-\frac{1}{2RC}}\right]$$

where α is the slope of the input-pulse leading edge and $p = j\omega$. The calculated results for three stages are shown in Fig. 4.

In order to chop up clutter a differentiating video amplifier using negative feedback through a non-linear device (Fig. 5) is used. The time-constant of the overshoots is extremely short. The recovery time of the logarithmic receiver after the strongest signals depends therefore mainly on its i.f. stages.

Mr. Rozenstein says in the paper that his logarithmic receiver improves observations of small targets in clutter even if they are close behind a strong target.



5 *Complete circuit diagram of differentiator and video amplifier*

Waveguide Propagation

A DIGEST OF A RADIO SECTION PAPER (No. 1763) ENTITLED "PROPAGATION IN CURVED AND TWISTED WAVEGUIDES OF RECTANGULAR CROSS-SECTION," BY L. LEWIN, ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

THE PAPER shows the solution of the wave equation for three configurations of rectangular-cross-section guide—by the use, as independent variables, of an axial co-ordinate and two cross-section co-ordinates. The form of solution is an expansion in terms of a parameter which represents the departure of the system from straight rectangular guide. For all waveguides considered the propagation coefficient involves the square of the expansion parameter, so that two steps in the expansion of the field give one term in the expansion of the propagation coefficient. The expansions have been completed for the first two perturbation terms in the field and the first term in the propagation coefficient.

For the circular bends the results are contained in the following formulae for the guide wavelength:

$$\frac{1}{\lambda_E^2} = \frac{1}{\lambda_g^2}\left\{1 - \frac{b^2}{12R^2}\left[1 - \frac{2}{5}\left(\frac{2\pi b}{\lambda_g}\right)^2\right]\right\} \quad \ldots \text{ (E bend)}$$

$$\frac{1}{\lambda_H^2} = \frac{1}{\lambda_g^2} + \frac{1}{24R^2}\left[1 - \frac{12+\pi^2}{2\pi^2}\left(\frac{2a}{\lambda}\right)^2 + \frac{15-\pi^2}{2\pi^2}\left(\frac{2a}{\lambda}\right)^4\right] \quad \ldots \text{ (H bend)}$$

where λ_E and λ_H are the guide wavelengths in the curved guide.

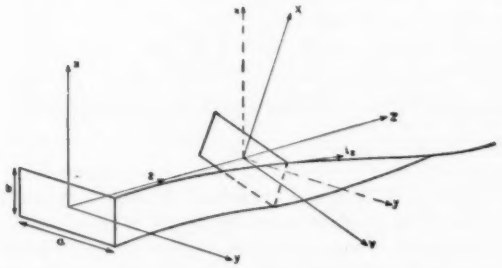
λ_g is the guide wavelength in straight guide.

R is the radius of bending of the centre of the guide cross-section.

a and b are the guide sides (a is normally greater than b).

The twisted waveguide is shown in Fig. 1. The guide wavelength λ_T is given by

$$\frac{1}{\lambda_T^2} = \frac{1}{\lambda_g^2} - \frac{1}{L^2}\left\{\left(\frac{1}{2} + \frac{\phi^2}{3}\right) + \left(\frac{a^2}{\lambda^2} - \frac{1}{4}\right)\left[6 + \pi^2 - 4\phi^2/3 + \frac{G(\phi)}{\pi^2\phi}\right]\right\}$$



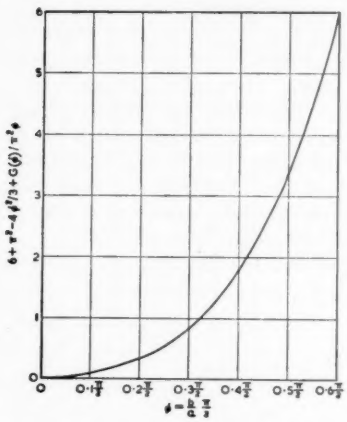
1 *Twisted guide and helical co-ordinate system*

where L is the length in which the guide has twisted through 360°, and $\phi = \frac{1}{2}\pi b/a$.

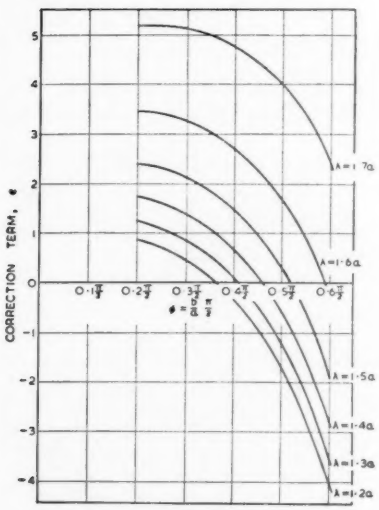
The expression in square brackets is plotted in Fig. 2 against ϕ. The equation can also be put in the form

$$\frac{1}{\lambda_T^2} = \frac{1}{\lambda_s^2}(1 - ea^2/L^2)$$

where the correction coefficient e is as plotted in Fig. 3. Although the correction term goes through zero within



2 *Plot of correction formula against ϕ for twisted guide*



3 *Plot of correction coefficient against ϕ for twisted guide*

the usual operating band, it is far from being numerically small; in fact as the guide cross-section approaches the square shape the correction becomes very large, showing the inadequacy of the expansion in this region. Since the expansion process involves a double summation per step, the next term in the propagation-coefficient expansion would involve a sixfold summation, from which it is apparent that the method of solution is unsatisfactory when further terms are required.

The problem of the twisted square guide remains unsolved.

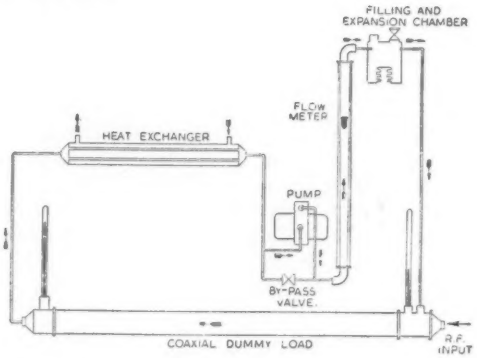
A Wide-Band Dummy Load

A DIGEST OF A RADIO SECTION PAPER (No. 1743) ENTITLED "A VERY-WIDE-BAND DUMMY LOAD FOR MEASURING POWER AT VERY-HIGH AND ULTRA-HIGH FREQUENCIES," BY W. HERSCH, B.SC.(ENG.), ASSOCIATE MEMBER. THE FULL PAPER WAS PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

THE PAPER describes a compact high-power dummy load which has a constant resistive input impedance over a very wide frequency range (100–3 000 Mc/s). The device is essentially a short lossy coaxial line in which nearly all the loss takes place on the inner conductor, which consists of a thin gold film on a glass rod. The resistance is graded in order to obtain uniform power dissipation.

A wide-band characteristic has been achieved by paying careful attention to the electrical and mechanical properties of the materials employed in the construction and by avoiding electrical and mechanical discontinuities.

The problem of dissipating large powers in a comparatively small space was solved by using liquid-cooled gold-film resistors, which can handle up to 45 watts/cm², although the actual design has been based on a much lower figure. Carbon tetrachloride is used as the dielectric and also acts as the coolant. This requires a closed cooling system, the schematic of which is shown in the Figure.



Schematic of closed cooling circuit

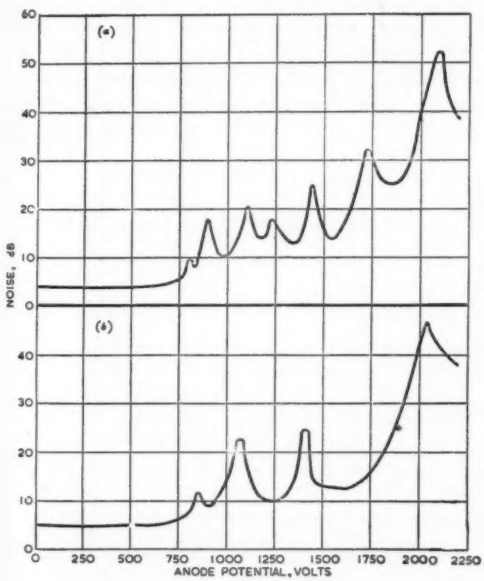
Power is measured in terms of the temperature rise between the inlet and outlet of a known quantity of the cooling liquid, with an accuracy of ± (2½% of measured power + 3 watts). The maximum power which the load can handle is 1 kW.

Noise in Cut-off Magnetrons

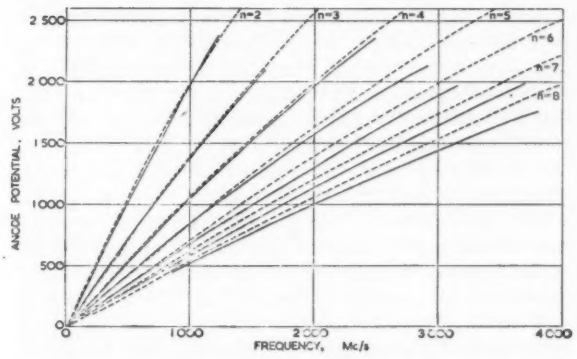
A DIGEST OF A RADIO SECTION PAPER (No. 1760) WITH THE ABOVE TITLE, BY R. C. GLASS, B.A., B.SC., G. D. SIMS, M.SC., B.SC., AND A. G. STAINSBY, B.SC. THE FULL PAPER WAS PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

WHEN A MAGNETRON is oscillating there is associated with the pure signal a fluctuation in amplitude and frequency of random character. Measurements at voltages below the oscillation level have shown that fluctuations in anode current are still apparent. The paper describes experiments made with a view to finding out more about these fluctuations. The authors made measurements in the cut-off region, i.e. at voltages such that in the absence of some disturbance, either mechanical or electronic, no current should pass to the anode. The noise output was studied in this region as a function of anode voltage, magnetic field strength and other parameters.

The noise output in a given bandwidth was measured over a wide range of frequencies, and it was found that at any frequency and for a fixed magnetic field the curve of noise against anode voltage showed one or more peaks as the voltage was increased from zero to the voltage of oscillation (Fig. 1). The voltages at which the peaks occur vary with frequency and they have been present at frequencies from 500 kc/s up to, in some cases, 4 000 Mc/s. When these voltages were plotted against frequency they lay on a series of curves diverging from the origin, and these curves bore a very close resemblance to those of the Hartree–Bunemann threshold-voltage relation, which gives the minimum voltages at which, theoretically, magnetron oscillation can start (Fig. 2). The authors obtained similar results when the frequency of measurement was held constant and the noise-voltage variation was measured for various magnetic fields.



1 *Typical noise/voltage curves for 10-segment valve* (H = *2 110 oersteds; anode diameter = 0·635 cm; cathode diameter = 0·325 cm*)
(*a*) 2 200 Mc/s. (*b*) 1 000 Mc/s.



2 *Peak-voltage/frequency curves for 10-segment valve* (H = *2 110 oersteds; anode diameter = 0·325 cm; cathode diameter = 0·325 cm*)
— — — Threshold lines. ——— Experimental lines.

The paper discusses a mechanism by which these noise peaks, or "pre-oscillations," arise in relation to the part that they may play in the operation of the magnetron, particularly with regard to the phenomena of build-up of oscillations and mode changing, i.e. the tendency of a magnetron to change frequency corresponding to a change in the configuration of the space charge. It seems likely that the probability of oscillation in one mode or another depends on the closeness of coincidence of an experimental pre-oscillation line with one of the theoretical threshold lines. This degree of coincidence is affected by change of the ratio of the anode and cathode diameters, and it may well be that the existence of these noise peaks accounts for the preferred ratios which are used when oscillation in a given mode is required.

Long-Distance Propagation

A DIGEST OF A RADIO SECTION PAPER (No. 1782) ENTITLED "REVIEW OF LONG-DISTANCE RADIO-WAVE PROPAGATION ABOVE 30 MC/S," BY W. J. BRAY, M.SC.(ENG.), MEMBER, H. G. HOPKINS, B.SC., PH.D., MEMBER, F. A. KITCHEN, B.SC., ASSOCIATE MEMBER, AND J. A. SAXTON D.SC., PH.D., MEMBER. THE FULL PAPER WAS PUBLISHED IN JANUARY, 1955, IN PART B OF THE PROCEEDINGS.

THE PART of the radio-frequency spectrum above 30 Mc/s accommodates short-distance services because of the comparatively rapid falling off of field strength beyond the transmitter horizon. Practical experience over the past 10 years has shown, however, that appreciable field

strengths are often produced well beyond the horizon. With the rapid increase in the exploitation of these frequencies, the risks of interference between stations are correspondingly increased. Furthermore, it would be of considerable importance if means could be found to include some long-distance services in this part of the spectrum, particularly if the bandwidth available to each service were greater than can be contemplated at the lower frequencies which are normally used for long-distance channels. These considerations provide the basis for a review of the situation at the present time.

As a starting-point, the authors consider theoretical predictions of field strength beyond the horizon over an ideally smooth earth. In accordance with usual practice, the radius of the earth is taken to be four-thirds of the physical radius to allow for refraction under "standard" meteorological conditions which exist when the air is well mixed. They discuss the effects of surface roughness and obstacles and pay special attention to the attenuating effects at centimetre wavelengths of water vapour, oxygen, fog, rain, hail and snow, since these reduce the strength of fields set up at long ranges; next they consider those properties of the ionosphere and troposphere which produce enhancement of field strengths beyond the horizon. The ionization in the F2 layer may be sufficiently intense to reflect energy back to the earth, particularly around the years of maximum sunspot activity. Rarely, however, will F2 propagation occur above 70 Mc/s, and the maximum usable frequency falls as the range is reduced from 4 000 km; on occasion, however, multi-hop transmission to greater distances is possible. Throughout the sunspot cycle, transmission may be practicable at various times by way of the sporadic-E layer on frequencies up to about 60 Mc/s over distances ranging from a few hundred to 2 000 km. In addition to these reflection processes, it has been found in recent years that scattering due to patchiness of ionization in the lower levels of the ionosphere produces weak, fluctuating, yet substantially continuous, signals in the lower part of the v.h.f. band at ranges up to about 2 000 km. In high latitudes, long-distance transmission by way of aurorae has been carried out on frequencies as high as 144 Mc/s, and this is another example of propagation involving the properties of an ionized medium.

The authors then turn to tropospheric effects in the un-ionized atmosphere relatively close to the earth's surface; so-called inversion layers are of importance in reflecting waves in the whole of the v.h.f. band from 30 to 300 Mc/s. The effectiveness of these elevated layers, where the refractive-index variation with height is steep, falls off with increasing frequency; but the more general effects of super-refraction, where the refractive-index profile in the vertical plane is such as effectively to decrease the curvature of the earth, are of consequence up to the highest frequencies in producing enhancement of field strength beyond the horizon. Finally, the scattering arising from inhomogeneities in the refractive structure of the troposphere due to turbulence has enabled weak signals to be received at frequencies in the v.h.f. band and higher, e.g. at 3 Gc/s* over paths up to 550 km. Subject to atmospheric attenuation due to the meteorological features mentioned earlier, future research may show that this scattering mechanism is of importance up to the highest frequencies in use.

* 1 gigacycle per second (Gc/s) = 1 000 Mc/s.

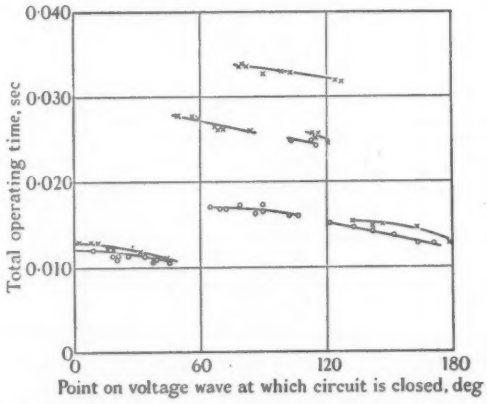
Pre-Loaded Fuses

A DIGEST OF A UTILIZATION SECTION PAPER (No. 1775) ENTITLED "THE EFFECTS OF PRE-LOADING ON FUSE PERFORMANCE," BY A. E. GUILE, PH.D., B.SC.(ENG.), ASSOCIATE MEMBER. THE FULL PAPER IS PUBLISHED IN FEBRUARY, 1955, IN PART A OF THE PROCEEDINGS.

WHEN A FAULT OCCURS on a fused circuit the circuit is usually carrying some initial load current. Standard tests, however, are made with fuses initially at ambient temperature, so that the time/current characteristics give times which are upper limit values.

Dr. Guile's paper describes an experimental investigation into the changes caused by pre-loading, in the operating characteristics of a fuse when clearing a fault. The fuses were subjected to a fault current from an alternator after they had been heated to steady temperature in a separate circuit, so that the rate of testing approached that of unloaded fuses.

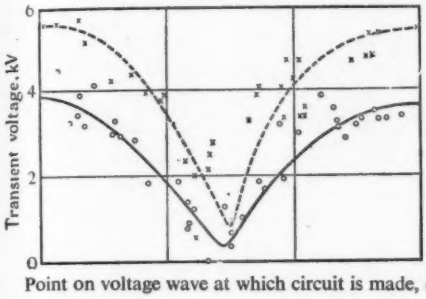
Tests were made with a constant prospective current at which the pre-arcing time of the fuse was of the same order as the time-constant of the circuit. As the point on the voltage wave where the circuit closed was varied over 180° by means of a timing circuit, while the circuit voltage remained constant, the current through the fuse was greatly affected by the d.c. component. Fig. 1 shows that the total operating time of an unloaded fuse in this condition varied by 300% (pre-arcing time by



1 *Variation of total operating time with the instant of circuit closure for a constant prospective current [100 amp (r.m.s.) in first cycle]*

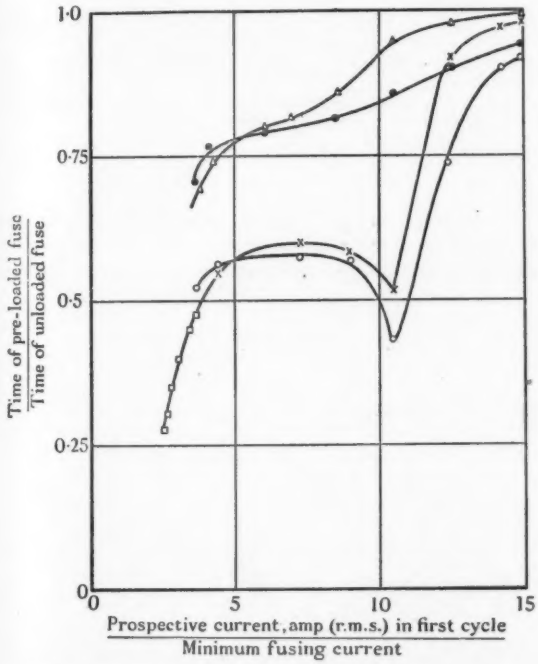
× × × Unloaded fuse.
○ ○ ○ Fuse pre-loaded at 90% minimum fusing current.

400%), depending on the instant of fault initiation. Pre-loaded fuses behaved similarly, but with times and ranges of variation which were smaller. The arcing time lay between 5 millisec and zero, and the transient voltage produced at the break-up of the fuse element varied from 5·5 kV to zero, as shown in Fig. 2. The large changes in



2 *Variation of transient voltage with the instant of circuit closure for a constant prospective current [100 amp (r.m.s.) in first cycle]*

× × × Unloaded fuse.
○ ○ ○ Fuse pre-loaded at 90% minimum fusing current.



3 *The effect of pre-loading on total operating and pre-arcing times*

△ △ △ Total operating time of fuse pre-loaded at 67% minimum fusing current.
● ● ● Pre-arcing time of fuse pre-loaded at 67% minimum fusing current.
× × × Total operating time of fuse pre-loaded at 90% minimum fusing current.
○ ○ ○ Pre-arcing time of fuse pre-loaded at 90% minimum fusing current.
□ □ □ Pre-arcing time of fuse pre-loaded at 90% minimum fusing current (low-current tests

pre-arcing time possible at a constant prospective current show the danger in plotting a single characteristic of pre-arcing time against prospective current. Tests made to specifications at a particular instant of circuit closure may not reveal the maximum transient voltage which the fuse is capable of producing.

Dr. Guile made a series of tests over a range of prospective currents with the circuit closed at 55 ± 5°. Fig. 3 shows that at prospective currents greater than about 15 times minimum fusing current, the change in total operating time due to pre-loading is negligible. At low over-currents, however, the reduction in total operating time is of an order which may need to be taken into account when one considers close discrimination between fuses, or between fuses and circuit-breakers.

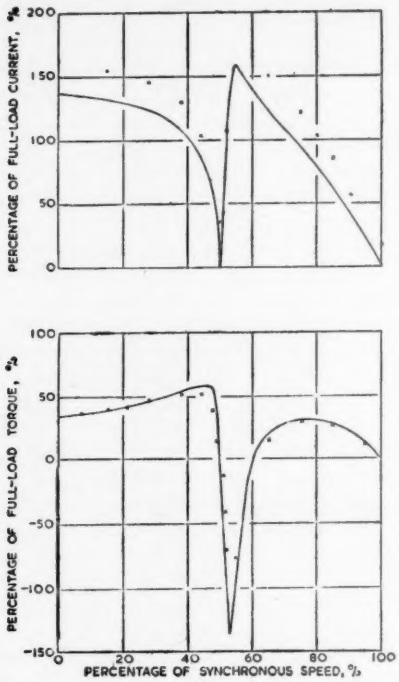
Pre-loading has the effect of reducing the transient voltage under all conditions (see Fig. 2). This is probably due to the temperature distribution along the wire at break-up being more peaked than in an unloaded fuse.

Above a certain current in a fuse the heat loss from the element can be neglected, and the pre-arcing time can then be calculated from the current-heat integral. The reduction in the value of this integral due to pre-loading was determined experimentally and by calculation. For the latter it was necessary to obtain the maximum element temperature rises for load currents up to minimum fusing current. These were found both by calculation and by means of temperature-sensitive pigments, with good agreement in the results.

Three-Phase Motors with Unsymmetrical Secondary Circuits

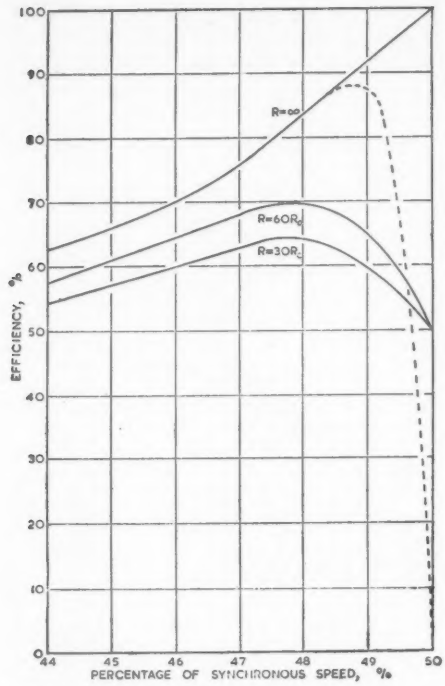
A DIGEST OF A UTILIZATION SECTION PAPER (No. 1784) ENTITLED "THE OPERATION OF THREE-PHASE INDUCTION MOTORS WITH UNSYMMETRICAL IMPEDANCE IN THE SECONDARY CIRCUIT," BY T. H. BARTON, PH.D., B.ENG., AND B. C. DOXEY, B.ENG., GRADUATES. THE FULL PAPER IS PUBLISHED IN FEBRUARY, 1955, IN PART A OF THE PROCEEDINGS.

IN 1896 GÖRGE NOTED that a polyphase induction motor with phase-wound secondary would run stably at one-half its normal speed if one secondary phase was open-circuited. The authors have investigated this phenomena in the more general case of the 3-phase motor with asymmetrical impedance in its secondary circuit. The general form of the torque/speed characteristic of such a machine is shown in Fig. 1. The asymmetry of the secondary impedance is responsible for the dip in the characteristic at one-half the normal speed; the greater the degree of asymmetry, the greater the magnitude of the dip. The dip may or may not be great enough to give negative torques over a range of speed immediately above one-half of normal speed. Hence, depending on the characteristics of the load torque, a minimum degree of asymmetry is essential to give half-speed



1 *Current/speed and torque/speed characteristics when one secondary phase is open-circuited*

Phase voltage is $1/\sqrt{3}$ times the normal value.
———— Predicted.
× × × Experimental.



2 *Efficiency/speed characteristics for various resistances in series with one secondary phase*

– – – – – Effect of magnetizing impedance.

operation, and speed control between full and half speed is impossible.

While the external secondary impedance may be resistive or reactive, or a combination of both, the best results are obtained if the impedance is purely resistive. The simplest and most useful divergence from the normal short-circuited secondary is obtained by connecting resistance in series with one phase, but an alternative of equal resistances in series with two phases has advantages in certain cases. With either alternative the machine can start against normal half-speed torque, but it is not possible to reduce speed from the normal value unless the load torque exceeds the peak positive torque just below normal speed. The efficiency at half speed depends upon the degree of asymmetry of the external impedance, increasing with increase of asymmetry as shown in Fig. 2.

When operating at the reduced speed the machine generates low-frequency currents. If these are objectionable in the supply network, their magnitude can be reduced—in the case of steady loads, to zero—by correct choice of the secondary external resistance.

Two independent rotating magnetic fields exist in the air-gap of the machine, and to avoid excessive magnetizing currents, the sum of their peak flux densities must not greatly exceed the normal value. This necessitates either a reduction in voltage or an increase in the size of the machine. In the former case the half-speed pull-out torque is approximately equal to the normal full-load torque.

Nuclear Power

A DIGEST OF A STUDENTS' PAPER ENTITLED "POWER PRODUCTION FROM NUCLEAR ENERGY," BY A. B. J. REECE, M.SC., GRADUATE. THE PAPER WAS AWARDED A STUDENTS' PREMIUM BY THE COUNCIL, AND A LONG ABSTRACT OF IT WAS PUBLISHED IN THE STUDENTS' QUARTERLY JOURNAL, SEPTEMBER, 1954.

THE RAPID INCREASE in demand for power, combined with the reduction in fuel reserves, has led engineers to examine methods of tapping other sources of energy. At present, attention is focused on ways of utilizing the energy released in nuclear fission, which offers a vast potential increase in world power reserves. Energy is available in the form of heat, which can be used to raise the temperature of the working fluid of a turbine driving a generator producing electrical energy.

Nuclear fission occurs, under favourable circumstances, when the nuclei of certain heavy elements are

bombarded by neutrons; the nucleus splits into fragments, and the combined mass of the fission products is less than that of the original nucleus. Mass is converted into energy according to Einstein's law. If, on the average, each fission produces just more than one neutron, in addition to those absorbed or lost from the surface of the material, the fission spreads throughout the fissionable material until some factor intervenes to limit the build-up of activity; a chain reaction is then said to occur. In this way, very large quantities of energy may be released. For example, the complete destruction of 1 kg of material by nuclear fission would result in the release of 25×10^9 kWh of energy, whereas combustion of the same amount of coal releases only 8·5 kWh of energy.

Natural uranium consists of approximately 99·3% of uranium 238 and 0·7% of uranium 235. Neutrons emitted with high energies are in the main slowed by uranium 238 without fission occurring. Slow neutrons produce fission principally in uranium 235. At a certain low velocity there is a strong absorption of neutrons by uranium 238, which prevents a chain reaction occurring. However, graphite or heavy water can be used to slow neutrons rapidly through the velocity at which absorption is a maximum, and the chances of producing a chain reaction are then increased. Natural-uranium reactors therefore need neutron-slowing materials or "moderators."

A chain reaction can be produced, without the use of a moderator, in uranium in which the percentage of uranium 235 has been increased. Production of enriched uranium involves difficult separation problems, since the two isotopes differ only in atomic weight. A chain reaction is also possible in fissionable materials such as plutonium, which is produced from uranium 238 in atomic piles as a consequence of neutron absorption. Reactors not using moderators are called "intermediate" or "fast," depending on the energy of the fission neutrons.

Although a natural-uranium power-producing reactor needs the least development from existing research reactors, it is essentially uneconomical in the use of fissionable material. It is estimated that as little as 1 part in 400 of this material may be consumed before refuelling is necessary. On the credit side, some of the uranium 238 will have been converted into plutonium, which can be used as fuel for other reactors or may be required for military purposes.

A possible method of improving economy in the use of fissionable material is through the application of the principle of breeding. If the core of a fast reactor is surrounded by a blanket of natural uranium or thorium, it is possible to make sufficient neutrons available to produce, by absorption in the blanket material, more secondary fuel than the primary fuel consumed. Breeding has been achieved in a small-scale power-producing reactor in the United States supplying heat to a 250 kW power unit. Chemical processing of the blanket material may prove difficult and costly.

A coolant is needed to remove heat from the reactor and transfer it to the working fluid of a turbine. The coolant must be chosen with care, bearing in mind that its nuclear properties affect the performance of the reactor and the amount of activity carried into other parts of the plant. It is desirable that it should be suitable for use at temperatures up to at least 500° C, preferably without pressurization of the containing circuit. Coolants for fast reactors must possess high heat-transfer coefficients, and liquid metals, principally sodium and sodium–potassium alloy, are especially useful in this field. They are, however, difficult to handle because of their extreme chemical activity, oxidation occurring readily and contact with water resulting in the release of hydrogen and a possible explosion. Circuits must be leak-tight and free from any material which will react with the liquid metal, and the free surface must be covered with an inert gas.

Because of the need for leak-tightness, special pumps having no moving parts and hence no shaft seals have been developed. These make use of the comparatively high electrical conductivity of the liquid metal, which allows an electromagnetic force to be produced on the liquid itself.

In the direct-current pump, a flat tube containing the liquid metal is situated between the poles of a d.c. magnet system. A heavy direct current is passed through electrodes brazed to the tube sides, the current crossing through the liquid metal in a plane at right-angles to the field. A force is developed on the liquid metal, pushing it along the tube. A disadvantage is that a very-heavy-current low-voltage supply is needed. If the field coils are series-connected, the pump can be operated from an a.c. supply with reduced efficiency.

The heavy currents in the liquid can be produced by induction, and two basic forms of induction-type pump have been used. In one of these, the stator is similar to that of a normal induction motor. Liquid flows between two concentric tubes in the annular gap between the stator and stationary inner core. The force is developed in the circumferential direction, but helical guide vanes in the annulus give the flow an axial component. The second type consists of two flat slotted and laminated cores, each wound with a 3-phase winding, with a flat tube containing the liquid lying between the cores. When excited the winding produces a travelling field, and the reaction between the flux and induced currents produces a force on the liquid.

The foregoing indicates some of the principles involved in the release and utilization of nuclear energy. Although the future is promising, many problems remain to be solved before nuclear energy can make an appreciable contribution to world power requirements.

HOME EVENTS

LONDON

MEASUREMENTS SECTION

At the meeting of the Section on the 23rd November, 1954, Professor H. E. M. Barlow presented two papers, one on *The Application of the Hall Effect in a Semi-conductor to the Measurement of Power in an Electro-magnetic Field,* and another* on the design of watt-meters based on this principle. He was followed by Dr. A. H. M. Arnold, who introduced a paper on *Audio-Frequency Power Measurements by Dynamometer Watt-meters.* Digests of these papers will be found on pages 76 and 77.

There has hitherto been little demand for measure-ments of electrical power at audio frequencies, but, with the increasing use of these frequencies in aircraft and other applications, the shortcomings of ordinary wattmeters when used beyond their designed frequency limit have become apparent. It was particularly appro-priate, therefore, that these two authors should have presented their papers on the same evening, for each offered a solution to the problem, though the solutions took widely different forms. Professor Barlow has produced a wattmeter on an entirely new principle, although the Hall effect on which it is based has been known for the better part of a century. Dr. Arnold described the errors to which the traditional dynamo-meter wattmeter is susceptible, and gave an account of how the instrument may be improved and how it should be used at frequencies up to 20kc/s.

If a conductor which exhibits the Hall effect is caused to carry a longitudinal current and is at the same time subjected to a transverse magnetic field, an e.m.f. is set up at right angles to the magnetic field and to the current. In Professor Barlow's wattmeter a crystal of germanium, which has a large Hall coefficient, is placed in the mag-netic field of the load current, while a current proportional to the load voltage is passed through it. The Hall e.m.f. which is developed is then proportional to the power in the load. Alternatively the current through the crystal may be proportional to the load current while the field is proportional to the load voltage. Either arrangement constitutes an extremely simple wattmeter which can theoretically be used up to even ultra-high frequencies. Professor Barlow demonstrated a wattmeter in which the small Hall e.m.f. was measured by a photocell amplifier. The accuracy claimed was within about 5% at 20kc/s.

Dr. Arnold analysed the errors of the dynamometer wattmeter and reviewed the methods of avoiding those that arise from stray capacitance and eddy currents. Screening of the load is desirable and screening of the wattmeter is essential at the higher frequencies, and Dr. Arnold described methods of connecting the screens and of inserting the instrument into circuit, both for load measurement and for calibration. He went on to show how the inherent defects in a dynamometer wattmeter could be rendered unimportant by the use of electronic amplifiers, and demonstrated an instrument with an amplifier in both current and voltage circuits. The accuracy claimed was B.S. Precision Grade at 20kc/s.

Professor R. O. Kapp, opening the discussion, was overwhelmed by the vista of possible developments opened up by the Hall-effect instrument. He foresaw that it could be used as an ammeter, voltmeter, watt-meter, VAr-meter or protective relay. Its advantages were its frequency independence, its simplicity and its freedom from saturation at high overloads. He was particularly attracted by the possibility of using it instead of current transformers in e.h.v. bushings. It was true that its output e.m.f. was small, but he saw no reason why amplifiers, either electronic or magnetic, should not be used in conjunction with it.

Mr. A. Hobson, having spent most of his working life making current transformers, was perturbed to hear Professor Kapp suggesting that they might become obsolete. He comforted himself, however, by reflecting that the Hall-effect instrument had a long way to go before it could compare in performance, size, weight or convenience with a current transformer at power fre-quencies. It might, however, be very useful for ultra-high frequencies, since it was one of the few devices that could be calibrated at a low frequency and used at high frequencies. Mr. W. Bamford doubted whether the new device would replace conventional methods for d.c. measurements. With heavy currents, shunts admittedly consume too much power, but the d.c. current-transformer gives satisfactory service, and there is plenty of output for meters and instruments.

Dr. E. Billig pointed out that, although the Hall effect had been recognized for a long time, it was hardly the fault of our predecessors that it had not been put to some use, for materials having a large Hall coefficient, such as some of the semi-conductors, had not long been available. A new class of compounds, of which indium antimonide is one, was now being investigated. The electron mobility far exceeded that in germanium even, and such materials might well be used in Professor Barlow's instrument. The ability of the instrument to measure products might make it useful in computing machines.

Referring to Dr. Arnold's paper, Mr. H. D. Hawkes emphasized the advantages of a screened, null, reflecting,

* "The Design of Semi-conductor Wattmeters for Power-Frequency and Audio-Frequency Applications."

dynamometer instrument, preferably with electrical counter-torque, for the measurement of current, voltage and power to an accuracy of within 0·2% up to 2kc/s. Mr. F. W. Axworthy was equally enthusiastic about amplifier-operated electrostatic instruments, which could now be made in a portable form.

Both authors briefly replied to the discussion, and Mr. M. Whitehead from the chair proposed a vote of thanks to them, expressing his admiration for the ingenuity and hard work that had gone into combining old principles with new techniques. A. F.

RADIO AND MEASUREMENTS SECTIONS

Standard Frequency Transmissions

The three papers on Standard Frequency Transmissions (s.f.t.), read at a joint meeting of the Radio and Measurements Sections on the 10th November, 1954, represent a milestone in this specialized and important field. With the ensuing discussion, they clearly demonstrate that the work carried out by the National Physical Laboratory, the Post Office and the Royal Observatory is that of a closely integrated team and has put the United Kingdom in the forefront of the subject.

In his introductory paper (*Standard Frequency Transmissions*), Dr. L. Essen reviewed the history of s.f.t. in the United Kingdom and outlined the service which has been provided from the P.O. Radio Station at Rugby since May, 1954, on frequencies of 60, 2 500, 5 000 and 10 000kc/s, with the call sign MSF. The results quoted show that in general the transmitter frequencies are maintained within one part in 10^8 of the nominal frequencies, and the finally accepted values of the associated time signals are maintained within one part in 10^8 of their nominal values. Doppler variations of the frequency of the signal received at a distance might, about sunrise and sunset, be as high as two parts in 10^7 for all but the 60kc/s emission, which is not seriously affected. Dr. J. A. Pierce of the Cruft Laboratory, Harvard University, regularly compares the frequency of a local standard with that of the received 60kc/s signal to within two parts in 10^9.

The problems met with in the provision of a 24-hour service from MSF were discussed by Mr. H. B. Law of the Post Office in his paper entitled *Standard Frequency Transmission Equipment at Rugby Radio Station*. He outlined the designs employed to ensure continuity of operation and high accuracy of both the frequency and the associated time signals. The solution has been well proven, and it is of interest to note that the highest-grade quartz clock can be installed and operated effectively under ordinary radio-station conditions. In conclusion, Mr. Law demonstrated the precise comparison of a local 100kc/s crystal oscillator with the 60kc/s transmission.

The third paper, by Mr. J. McA. Steele on *The Standard Frequency Monitor at the National Physical Laboratory*, described the equipment designed and installed at Teddington for the automatic measurement and recording at the Laboratory of both the frequency and time signals emitted by MSF. Here again, the great care and attention which have been given to the design of all the equipment providing the MSF service were apparent. A digest of the paper appears on page 78.

In opening the discussion, Dr. R. L. Smith-Rose outlined the need for the transmissions and explained that, after discussions between the Government Departments concerned, it had been decided that the N.P.L. should be responsible for the technical aspects of the service and, through the Department of Scientific and Industrial Research, should pay the Post Office for the transmission. Thus the responsibility for the accuracy of the transmitted frequencies was with the N.P.L. Mr. H. M. Smith of the Royal Greenwich Observatory indicated the Observatory's responsibility for the establishment of fundamental time upon which the transmissions are based, and Mr. J. Wellgate described the monitoring of the transmissions. A plea was made by Mr. R. J. S. Spilsbury for confirmation from users that the service was meeting their needs and, if not, for suggested changes. Both Mr. N. Lea and Mr. H. V. Griffiths commented on the accuracy of the transmissions and their usefulness. Mr. H. T. Mitchell referred in some detail to the heart of the MSF installation—the modified Essen quartz ring. With some pride he said that, of the 38 rings then in use, several were operating in Australia, the United States and Canada.

The authors replied briefly to the discussion, and Dr. Essen took the opportunity of mentioning that the frequency of the Post Office telegraph transmitter GBR, 16kc/s, is controlled to the same accuracy as MSF. This, he indicated, might be very useful since the transmitter provided a world-wide service.

In conclusion, the Chairman of the Measurements Section, Mr. M. Whitehead, proposed a hearty vote of thanks to the authors, in the course of which he told of the man who, each morning, set his watch by the clock in the local jeweller's. One day the jeweller asked why he did this. The reply was "I am responsible for setting off the hooter at the local works." "But," said the jeweller, "I set my clock by that hooter." May it be that there was a similar tendency in the past between the measurers of time and frequency? C. F. B.

RADIO SECTION

Medium-Frequency Broadcasting Aerials

The paper on *The Vertical Radiation Patterns of Medium-Wave Broadcasting Aerials* by Mr. H. Page and Mr. G. O. Monteath was read on the 1st December, 1954, before an audience which was small in regard to the importance of the subject and the quality of the paper.

In presenting the paper, Mr. Page said that very little had been published on the subject in the past 30 years, a fact which might be attributed to inherent experimental difficulties and, since the Second World War, to the concentration of attention on the v.h.f. services. By making use of model aerials the authors avoided the obvious physical difficulties in measuring the vertical radiation pattern (v.r.p.) of full-scale aerials, but they also had attempted to measure the v.r.p. of a mast aerial installed at Daventry by observation of the strength of the ionospheric reflections at various distances from the aerial. A digest of the paper appears on page 79.

The authors gave a convincing series of demonstrations of the v.r.p.'s of model base-fed and loop-fed aerials and of the way in which these patterns are modified when the aerials are set up on a conical hill or on a plateau. For the purposes of the demonstration, receiving aerials were used working in a field produced by a horn radiator energized at 2 000 Mc/s.

In the discussion on the paper, Mr. G. Millington complimented the authors on an important piece of work. He asked whether the results of their work at Daventry had resulted in a flood of letters from satisfied listeners. He suggested humorously that listeners might co-operate with the B.B.C. by installing in their back yards anti-fading aerials of the type described in the paper.

Mr. P. P. Eckersley, who had risen from a sick-bed to attend the meeting, spoke of his past interest in the subject and suggested that the 25-year-old paper by T. L. Eckersley, H. L. Kirke and himself* might be mentioned in the references, if only for sentimental reasons. The main aim in those days was to increase the power in the ground wave rather than to modify the v.r.p. in order to reduce the ionospherically reflected waves. No model-aerial tests were then possible; 2 000 Mc/s, said Mr. Eckersley, would have seemed "like light" to him 25 years ago. He had supported half-wave aerials on a kite balloon on Salisbury Plain; experiments were difficult and the tabulation of the results in the paper quoted was "more impressive than true." Nevertheless, it had been the policy of the B.B.C. to use half-wave aerials since his tests were carried out.

Mr. J. K. S. Jowett was interested in the possibility of improving the service area of synchronized networks, such as those carrying the Light Programme, by using the principles considered in the paper. Some information on the increase with frequency of the intensity of ionospheric reflections in the m.f. band was presented by Mr. W. R. Piggott.

In replying to the discussion, Mr. Monteath said that the inauguration of the Daventry mast radiator had been accompanied by an increase in transmitter power; this explained why no reports specifically on the aerial performance had been received from listeners. Commenting on how the efforts of the B.B.C. to give a fading-free service were received by the listener, Mr. Monteath quoted the case of one listener—a radio engineer—who uses a horizontal aerial with no earth connection, and who relies for reception, therefore, on the field which Mr. Page and he had striven to remove. Mr. Monteath expressed the authors' gratitude to Mr. Eckersley for repairing their omission in referring to the work of the past giants of the B.B.C.

The Chairman expressed the thanks of the meeting to the authors for their excellent paper and demonstration. He considered that the paper showed all the signs of becoming a classic. A. F. W.

* Eckersley, P. P., Eckersley, T. L., and Kirke, H. L.: "The Design of Transmitting Aerials for Broadcasting Stations," *Journal I.E.E.*, 1929, 67, p. 507.

SUPPLY SECTION

Joint Meeting with The Institution of Mechanical Engineers

Mr. J. D. Peattie gracefully yielded his chair to Mr. W. B. Shannon, Chairman of the Steam Group of The Institution of Mechanical Engineers, for the joint meeting with that Group on the 24th November, 1954, when two papers were given on the measurement of small movements, distortions and vibrations in steam turbo-rotors.* Starting from much the same primary transducer—an inductor varied by the shaft movement—the two papers showed a very interesting diversity in measurement technique. One described the use of a motor-generator and barrier-layer rectifiers, the other the use of thermionic valves: but both employed well-known telecommunication methods.

The discussion was opened by Mr. F. Shakeshaft (and what name, in the circumstances, could be more apposite?), who pointed out the very extensive programme for new generating plant in Britain, involving the installation of 140 sets, of ratings between 60 and 120 MW, and with steam up to 1 500 lb/in^2 and 1 000° F, in the next few years. Such machines expand a full inch between cold and hot, so that transient or sustained vibrations might indicate a condition of marked hazard. He felt that the "turbovisory" equipments described, costing less than one per cent of the machine cost, were good insurances at a very cheap rate, considering the probable consequences of a shut-down. One speaker foresaw, apparently with some foreboding, that a future station, run with an operating staff of one man per two megawatts, might require several times as many staff for the instrument servicing. Comdr. J. H. Joughin, bringing a breath of naval air into the Theatre, thought that land-station operators were lucky in bedding their machines on concrete, whereas he had flimsy foundations on which a satisfactorily-running land turbine would very quickly shake itself to a wreck.

As the discussion proceeded, a general burden became

* Antrich, D., Gardiner, H. W. B., and Hilton, R. K.: "Supervisory Equipment for the Indication of Shaft Distortion in Steam Turbines."
Ashworth, J. L., Hall, J. S., and Gray, A. H.: "The Electrical Measurement of Steam-Turbine Rotor Movements, with special reference to the Operation and Design of Modern Power Plant."

clear. The effectiveness of the pick-up devices in indicating vibration was generally conceded. But what did they tell one? How could measurements taken perforce near a bearing or shaft-end show what was happening in between? The heating of a rotor during the barring period showed peculiar and unexpected effects of distortion, which might well be far greater than the amount recorded by the magnetic signal devices. It was refreshing to hear the authors reply, quite frankly, that they did not know, but that the equipments did show that *something* was happening and, in time, with experience, it might be possible to interpret the indications with more insight.

Two interesting demonstrations were given to a crowd of attentive watchers at the close of the meeting. One showed a full-size dummy shaft recording its vibrations on an oscillograph. The other used a long, miniature shaft with a method of making measurements simultaneously at both ends of the shaft and summing them (after passing one through a phasing network) in an attempt to predict the conditions at the middle of the shaft.

The presentation of telecommunication techniques of measurement to the audience of "heavy, 50-c/s" engineers certainly indicated an aspect of the rapidly increasing overlap of the electronic and power fields. M. G. S.

Short-Circuits in Turbo-Alternators

There was a comparatively small but most interested audience, including many specialists in the subjects of design and operation of turbo-alternators, to hear Mr. J. B. Young and Mr. D. H. Tompsett present their paper entitled *Short-Circuit Forces on Turbo-Alternator End-Windings* on the 15th December, 1954. In the course of his introduction to the paper, Mr. Young showed photographic slides indicating some permanent distortion of end-winding conductors which had resulted from the application of a sudden 3-phase short-circuit from no-load at the rated voltage during a recent acceptance test on a 60 MW machine. Similar effects were shown on a short-cored replica stator with an identical form of end-winding bracing, but no distortion was observable on the other end of this model, which had been fitted with additional bracing.

Mr. Tompsett then outlined briefly the theoretical analysis of short-circuit forces presented in the paper and the measurements of leakage fluxes and deflections which had been obtained from the model. He concluded by showing an excellent film, taken by high-speed photography during a series of short-circuits, both of the whole and of a selected portion of the end windings of this model and of another full-size machine. By the use of a film exposure speed of some 1 660 frames per second in the close-up views, the audience were given a remarkable and alarming indication of what the authors rightly described as "struggling windings" in slow motion.

The authors' purpose in writing the paper had been to draw attention to the severity of this standard test applied to all alternators and to indicate its increasing significance in the larger units coming along. The possible adverse effect of the test on the subsequent life of a winding, even though the latter had been braced adequately enough to prevent permanent distortion, was particularly stressed. The authors invited discussion whether such a test at full voltage was justified in view of the less severe nature of most actual service faults, or, alternatively, whether the test should not be confined to a replica only.

Ten speakers took part in the full discussion which followed, and the views of both users and designers were heard. There was fairly general insistence upon the need to continue the proving of machines by a full-voltage short-circuit as a type test on the first machine. This was preferred to the building of a replica on the grounds of expense and the possibilities of variations in workmanship. It was claimed by several speakers that adequate bracing could be provided regardless of size, if the machine had suitable reactance, and the success of switchgear-testing alternators had shown what could be done even when very low reactance was essential.

L. D. A.

UTILIZATION SECTION

At the meeting on the 18th November, 1954, a paper was read by Mr. C. J. Beavis entitled *The Use of Electricity in the Production of Calcium Carbide*. The author outlined the history of the carbide industry, beginning with the discovery in 1836 of acetylene, referring to its commercial production by an electric furnace, which started in 1892, and dealing with the subsequent development of the manufacturing process from the early ingot-type furnaces to those of modern design producing "tapped" carbide. The remainder of the paper gave an interesting and detailed description of a typical modern carbide factory, and since, as the author pointed out, electrical energy can be regarded as its principal raw material, particular reference was made to those features of the electrical distribution which are peculiar to this industry.

As was natural with a paper of this character, the ensuing discussion very largely revolved around practical operating conditions and difficulties, and an interesting point which emerged was that the factory the author had described was rushed into production early in the 1939–45 war when supplies of carbide from Norway were cut off.

A question was raised whether, with a load of the magnitude of some 55 MW, operating at a power factor of 0·85 to 0·88, some form of power-factor correction would be desirable, and, touching this point, the author revealed that the installation of two static condensers, each of some 9 000 kVA capacity, was under consideration.

In dealing with a question on power cost, the author stated that this represented over 50% of the total cost of producing carbide. Several speakers, however, desired to know whether the actual terms of the power tariff could be made available, and, in this connection, one contributor (who confessed that he had taken part in the negotiations for this tariff) expressed the opinion that "the least said about the tariff the better," with which view the author later heartily concurred.

A somewhat obscure "nationalist" element was introduced into the discussion, when, on dealing with the troubles which had been experienced with deposits on insulators at the substation, the author referred to the effect of a "Scotch mist in Wales." Considerable discussion regarding the various faults which had occurred in operating the plant also took place, and the author is certainly to be commended on the very frank manner in which he dealt in his reply with this aspect of his subject.

R. H. R.

A Stimulating Meeting

At the meeting on the 9th December, 1954, Professor F. C. Williams and Mr. E. R. Laithwaite read their paper entitled *A Brushless Variable-Speed Induction Motor*. The authors explained that the squirrel-cage induction motor is based on the principle that a conducting sheet threaded by a magnetic field moving parallel to the sheet will assume a velocity equal to that of the field if it is free to move. They then went on to describe the research which they had carried out to discover what would occur if the sheet was constrained so that it could move only in its own plane and in a direction making an angle with the direction of motion of the field. Having calculated that in certain circumstances the sheet should travel at a speed in excess of the speed of the field, they found by experiment that the speed of a copper disc could be varied if this rotated between a pair of "square" linear stators, which could be turned at any chosen angle to the motion of the copper under the poles. This effect was made the basis for the design of a variable-speed brushless induction motor, and the experimental machine which was constructed was demonstrated to the meeting in actual operation. The authors discussed in detail the results they had achieved with the machine. A digest of the paper appears on page 81.

The well-attended meeting clearly showed that this particular paper had aroused considerable interest, and, as was perhaps inevitable, contributions to the discussion came mainly from members engaged in either the designing or teaching branches of the profession. It was evident that there was a consensus of opinion that the novel effect which the authors had described fully warranted further research and development, and, as one speaker remarked, if anybody could invent a variable-speed a.c. motor which had no wasteful losses and no sliding contacts, it would be the end of d.c. systems altogether and it would completely revolutionize electric power drives.

One interesting observation was that this paper presented a great opportunity to designers to examine again the fundamental principles of machines, and to look at the induction motor application to see what could be done to develop it.

Meetings in The Institution building where a novel principle in power engineering is described are few and far between these days. No doubt many present on this occasion wondered whether they were recapturing a little of the stimulating atmosphere which surely must have prevailed at those meetings in the early years of The Institution, when the pioneers of our profession put forward their various discoveries in electrical science.

R. H. R.

GLASGOW

SCOTTISH CENTRE

A Record Attendance

The Annual Dinner-Dance of the Scottish Centre took place at the Grosvenor Restaurant, Glasgow, on the 16th November, 1954, when about 280—a record number—members and guests assembled under the chairmanship of Mr. J. S. Hastie; in welcoming the guests Mr. Hastie referred to the absence of his valued friend and mentor, Professor G. W. O. Howe, who was unable to be present since he was at that moment delivering in London a special lecture at The Institution's celebration of the Jubilee of the Thermionic Valve.

The toast of "The Institution" was proposed by Sir Hector Hetherington, Principal and Vice-Chancellor of the University of Glasgow, who spoke of the enthusiasm, loyalty and high professional standard of engineers, who had given mankind the unspeakable blessings of electric light and power. In replying, Colonel B. H. Leeson, Past-President, urged those present to weave into the fabric of everyday life not only the threads of electrical science but also the golden threads of honest human endeavour towards nobler things, thus enriching human life throughout the world. At the end of Colonel Leeson's speech Mrs. Hastie, with some exceptionally charming and effective words, presented the Hutcheson–Winning Golf Trophy, won at Pitlochry during the Summer Meeting, to Mr. W. J. A. Gemmell. The toast of "The Guests and Kindred Institutions" was proposed by Mr. W. J. Rennie, Chairman of the South-West Scotland Sub-Centre and replied to by Mr. N. M. Brydon, Vice-Chairman of the Glasgow and South-West Scotland Association of The Institution of Civil Engineers. The final toast of the evening—"The Chairman"—was proposed by Mr. D. J. W. Harvey, Vice-Chairman of the Scottish Centre, who referred to Mr. Hastie's outstand-

ing work for The Institution over many years, a sentiment that was most heartily endorsed by all present.

E. O. T.

NORWICH

DISTRICT MEETING

Mining in East Anglia

The second meeting of the session was held at the Assembly House, Norwich, on the 30th November, 1954, when a paper on *The Technique and Development of Automatic Winding in Mine Shafts* was read by Mr. G. Cuttle, who has written the paper in collaboration with Mr. B. L. Metcalf.

Mineshafts are conspicuous by their absence in Norfolk, and it was not to be expected that there would be many experts on this subject among the audience. Mr. Cuttle, however, soon showed that this is a field where many fascinating problems are encountered, and from the lively discussion which followed it was clear that the interest of the members present was fully aroused.

Mr. J. A. Sumner occupied the chair, and a vote of thanks to Mr. Cuttle was moved by Dr. B. Schwarz.

J. A. S.

READING

DISTRICT MEETING

In spite of the bad weather, an enthusiastic audience of 49 attended the District Meeting at Reading on the 29th November, 1954, at which Mr. K. R. Seamans gave a lecture on *Television Interference*.

A number of lantern slides were shown illustrating television receiver faults which are commonly mistaken as being caused by external interference. Mr. Seamans followed these by considering receiver design characteristics which cause a receiver to accept or accentuate interference from random sources or unwanted transmissions. Suggested limits of radiation from local oscillators were quoted, together with the new standard intermediate frequencies proposed by the British Radio Equipment Manufacturers' Association. The lecturer discussed and illustrated the influence of aerials on multiple-path reception, and the interference caused by various small domestic appliances; he described methods of suppression and covered the latest developments in the design of suppression components, showing various examples of small multiple suppressors. Mr. Seamans then considered external interference and illustrated its effects with lantern slides: he included in his discussion interference from internal-combustion engines, radio-frequency heaters and medical equipment, radio transmitters, radar and navigational aids, overhead power lines, and, finally, filament lamps.

The lecturer ended on aspects of the suppression of interference in Band 3 and with a demonstration of the receiving sets for locating and measuring interference which are in current use by the Post Office, and this was followed by a long and stimulating discussion. Mr. W. F. Sands presided and the thanks of members were ably expressed by Captain M. C. Gray.

H. R. J. B.

SWANSEA

WEST WALES (SWANSEA) SUB-CENTRE

Safety Precautions

The opening meeting of the session was held on the 14th October, 1954, in the Conference Room above the new showrooms of the South Wales Electricity Board in Swansea, and at this meeting Mr. G. D. Curtis, the new Chairman, delivered his Address. Mr. Curtis outlined the precautions taken to avoid danger when electricity is used in explosive atmospheres. After tracing the development of flameproof gear, he covered matters of particular interest to the chemical and petroleum industries, and finally dealt with the uses and limitations of intrinsically safe apparatus. After the meeting, a number of members inspected the Electricity Board's new premises, and they showed particular interest in the electrically heated flooring, some of which was still under construction.

The second meeting was held at the Plaza Cinema, Swansea, on the 11th November, 1954, when Mr. J. W. Bunting's paper entitled *Safety in the Use of Portable and Transportable Electrical Equipment in Industry* was read by Mr. P. R. Gray. From the discussion which ensued, it was clear that the members were largely in agreement with the views expressed in the paper.

Dining and Dancing

The Annual Dinner and Dance were held on the 12th November, 1954, at the Langland Bay Hotel, Mumbles, and the function was honoured by the presence of Dr. Willis Jackson, Vice-President, Mr. R. B. Southall, and a number of other visitors. Mr. Southall, who proposed the toast of "The Institution," referred to the training of electrical engineers and the part that engineers are playing in developments now taking place in South Wales. Dr. Willis Jackson, in replying to the toast, made further reference to technical training, and the need, by our future engineers, of greater basic knowledge. The toast of "Our Guests" was proposed, at short notice, by Mr. J. H. Groocock in place of Mr. E. W. Cooper, who was unable to attend through illness. The Mayor of Swansea, Alderman T. S. Harris, in replying to the toast, amused the company with a fund of stories. The toast of "The Chairman" was proposed by Mr. E. Hywel Jones, Vice-Chairman of the Western Centre. The dance, which followed, owed much of its success to the M.C.s, Mr. L. Benallick and Mr. T. Gill.

R. F. D.

NEWS *from abroad*

IRELAND

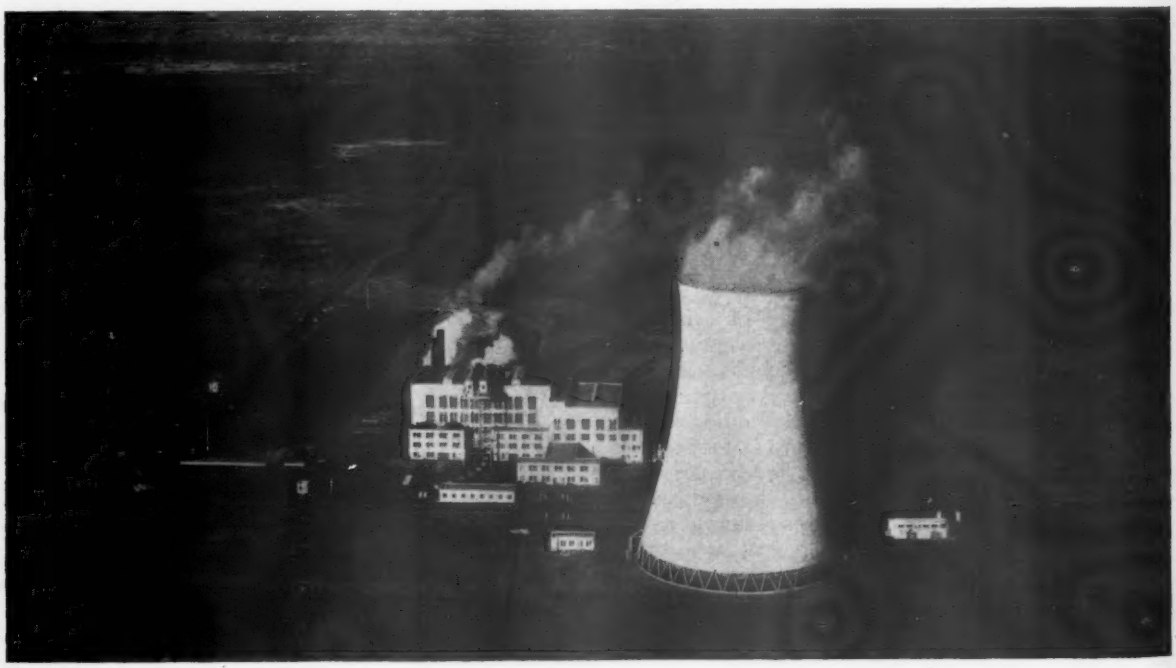
The 1954–55 Session began, as is customary, with the Chairman's Address, in which Dr. R. C. Cuffe gave a most interesting historical account of the pioneer work of Irish scientists on the fundamental principles of magnetism and electricity, particularly of work carried out contemporaneously with that of Michael Faraday. The Address brought to light many Irish scientists whose names even were unknown to many of those present. In connection with the history of electrical engineering in Ireland, it may be recorded that a "Preliminary General Meeting" to form an Irish Section of The Institution was held in Dublin at the Royal College of Science for Ireland on the 27th October, 1899. Amongst those present were Professor W. F. Barrett (in the chair), Professor G. F. Fitzgerald, F.R.S. (Trinity College, Dublin), and Frank Gill (later Sir Frank Gill and a President of The Institution). The Irish Section was duly formed with the approval of the Council, and the first General Meeting was held on the 5th January, 1900. Eventually the Section became a Centre; and in recent years the Centre has become an Oversea Branch.

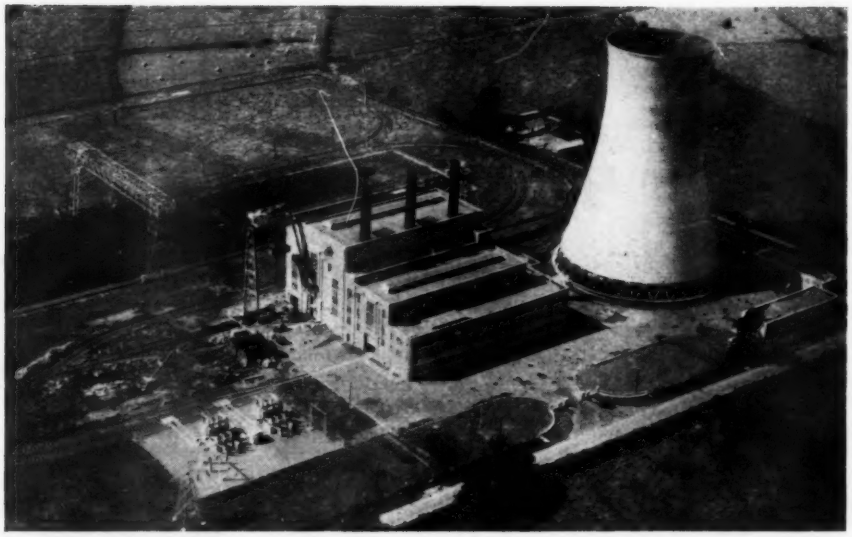
Membership figures for all classes of members, particularly Graduates and Students, continue to show encouraging increases in Ireland. There is a possibility of forming a Students' Section in Dublin, and some experimental meetings are to be held.

It may be of some general interest to refer here to the expanding use of peat (or "turf") fuel in Ireland. Peat is the only fuel available in Ireland in large quantities and, in the absence of adequate coal supplies during the Second World War, was extensively used for domestic purposes in the form of sods. Sod peat is, however, not very suitable for the ordinary domestic fire grates with narrow chimneys, because of its high moisture content, which causes a deposit of inflammable turf wax in 9in flues, a deposit which can result in a very serious flue fire. Hand-won sod peat has been used, of course, for centuries as fuel in thatched cottages in the country; but unlike city and town dwellings these cottages have large open hearths with very wide chimneys, so that the risk of chimney fires due to turf-wax deposits is exceedingly small. Peat briquettes, from which excess water has been removed under high pressure, are now available for towns.

It has for long been the desire of the Irish Government to exploit, for economic and security reasons, the very large quantities of peat available in the bogs throughout the country. The Turf Development Board was established in 1933 to make a comprehensive survey of the bogs, and to undertake the winning of turf by the most modern methods of mechanization. The Second World

Aerial view of Allenwood generating station, Co. Kildare





Aerial view of Portarlington generating station, Co. Offaly

War caused a halt to the Board's activities, but towards the end of it a statutory Corporation was set up "to develop the turf resources of Ireland." This body is known as "Bord na Mona" (Turf Board) and it has at present about 100 000 acres of bog under development for mechanical winning of both sod and milled peat. It is estimated that there are another 300 000 acres suitable for production of fuel. Some 250 miles of overhead line are used for distribution of electrical energy in the bogs. The peat-cutting machines are supplied at 3·3kV through trailing cables.

Because of its great bulk compared with that of coal of equivalent calorific value, peat is very costly to transport, and takes up considerably more storage space than does coal. The obvious remedy for these drawbacks is the erection of electricity generating stations as close as possible to the bogs, so that the peat fuel is utilized on the spot for the transmission of electricity to industrial and private consumers. The Government have not been slow to put this plan into effect, and by close co-operation between the two statutory bodies, Bord na Mona and the earlier established Electricity Supply Board, peat-fired generating stations are now in operation at Portarlington and Allenwood. These stations use sod peat.

A further interesting development in the use of peat for power production in Ireland is at present being undertaken by the Electricity Supply Board, namely the construction of a generating station near Ferbane, Co. Offaly, some 80 miles west of Dublin. It will be the first of its kind outside the U.S.S.R. to use *milled peat*. Its construction will take place in two stages. In the first stage it will be equipped with three 220 000lb/h boilers and three 20MW turbo-generators. Two cooling towers, each 266ft high and 185ft in diameter at the base, will be provided for the cooling-water system. This first stage is due for completion in 1956–57 and will provide an output of approximately 240 million kWh per annum. The second stage will include the construction of two additional boilers and two further turbo-generators, with a third cooling tower. The output then will rise to 400 million kWh per annum, using 920 000 tons of milled peat. Two more milled-peat-fired generating stations of equivalent size are under consideration.

The first "International Peat Symposium" was held at the College of Science, Dublin, in July, 1954, and 12 countries participated.

The use of peat-fired stations alone would not nearly suffice to meet the rapidly increasing demand for electricity, and the Electricity Supply Board have recently commissioned a 60MW dual-fuel(coal and oil)-fired station at Marino, Cork, with an ultimate capacity of 120MW. Within the next year it is hoped also to have a new station at Ringsend, Dublin, in operation. This station will, likewise, be dual-fuel-fired, with an initial capacity of 90MW and provision for extension up to 210MW.

J. D. F.

OVERSEA ATTENDANCE REGISTER

During the period 1st December to 31st December, 1954, the following members called at the Institution Building and signed the Attendance Register of Oversea Members:

BUTTERWORTH, E. G. **(Wellington)**.
CRITCHLEY, O. H., M.Sc. **(Salisbury, S. Australia)**.
DAVISON, R. C., M.Sc. **(Wellington)**.
DHARAP, K. P. **(Bombay)**.
HARDY, F. E. M., B.Sc.(Eng.) **(Kirkuk, Iraq)**.
OWEN, A. E. S., B.Sc.Tech. **(Melbourne)**.
SPROUL, R. W. **(Montreal)**.

Journal I.E.E., February 1955

Some recent impressions of the WEST INDIES

S. L. M. BARLOW, *Associate Member*

Many members will be following Princess Margaret's current tour with close attention. Mr. Barlow has made many visits to the West Indies and he has a first-hand knowledge of their affairs, and in particular of the progress of electrical engineering in the islands. The economy of the West Indies is at present changing rapidly, and there are likely to be great opportunities in them for British engineering enterprise in the years immediately ahead.

ALTHOUGH it was over four-and-a-half centuries ago that Christopher Columbus first sighted San Salvador in the Bahamian group of West Indian islands, thus creating new fields for the expansion of western civilization, no spectacular progress in such expansion occurred in the West Indies until the start of the Second World War. Perhaps the greatest factor contributing to this more recent development has been the advent of air travel, for the many hundreds of small islands which go to form the West Indies are dispersed over a wide area bounded by North, Central and South America, and by the Atlantic Ocean.

During the Second World War it became necessary to construct aerodromes and air-strips on many of these islands in order to secure the defence of the territories and to keep open our sea lanes. Ironically enough, it has been this war-time constructional programme which has brought post-war prosperity to the peoples of the West Indies. This increased prosperity is, however, still young and very far from being universal, and so, for those who have failed to benefit, it has served only to whet the appetite and cause some resentment and discontent. This reaction is perhaps most apparent in Jamaica, the largest of the British islands, where, with a population already approaching the one-and-a-half million mark and both unemployment and the birth-rate high, industrial progress is still much too slow. One effect of this reaction is the present influx of Jamaicans into Great Britain. These, and others from the West Indies, have witnessed in their own countries the apparent prosperity of the increasing number of tourists from the United States and Great Britain, and see in their rights as British citizens a golden opportunity of coming to Britain to learn a trade or profession, while earning high wages in a country that at present enjoys much welfare and little unemployment.

1 *The recently constructed Emerald Beach Hotel, Nassau, Bahamas*

Industry and Trade

From the Bahamas in the north to Trinidad in the south is some 1 600 miles as the crow flies, and prior to 1939 almost the only contact in this vast island area was by sea. It is true that a few pioneers, to whom great credit is due, had set up small if somewhat erratic air services between some of the larger islands, but the sea was the main means of transportation. It is not therefore surprising that the time involved in travelling from island to island with the prospect of limited trading opportunities failed to attract business men, who preferred to concentrate their energies in easier fields. For a similar reason few tourists were able to spare time to take passage in the small craft plying between all but the larger islands.

Thus it was that, in the main, trade was restricted to the import of the necessities of life and the export of the traditional West Indian products such as sugar, rum, molasses, tobacco, coffee, cocoa, bananas, spices, citrus fruits, copra, rice, certain hardwood timbers, and cotton. This business was in the hands of a relatively few specialist companies who had laboriously built up their businesses over centuries and had slowly improved the standard of living in the area. As is usually the case, there were exceptions to this type of trade, for in Trinidad the production of oil and asphalt had brought greatly increased prosperity to the island, while in British Guiana, on the mainland of South America, small quantities of diamonds and gold were located. With the increased use of aluminium the rich bauxite deposits of British Guiana became of great importance and were mined in quantity, bunkered and refined in neighbouring Trinidad, and shipped chiefly to Canada for the production of aluminium.

Since the end of the Second World War, however, there has been an awakening in the West Indies, many new industries have sprung up, and the tourist trade has increased beyond belief, resulting in the construction of

new factories, hotels and shops. Mining has been greatly expanded so that bauxite is now produced in Jamaica also, manganese in British Guiana and cement in Jamaica and Trinidad, while agriculture has been materially extended, particularly in such products as rice, citrus fruits and hardwoods. It is interesting to note that Trinidad has now augmented its hardwood industry by planting teak forests in the island.

Under a pioneer industrial scheme which is gaining momentum, many small local industries have been started, so that some everyday materials such as paint are now manufactured locally, bringing increased employment and stability.

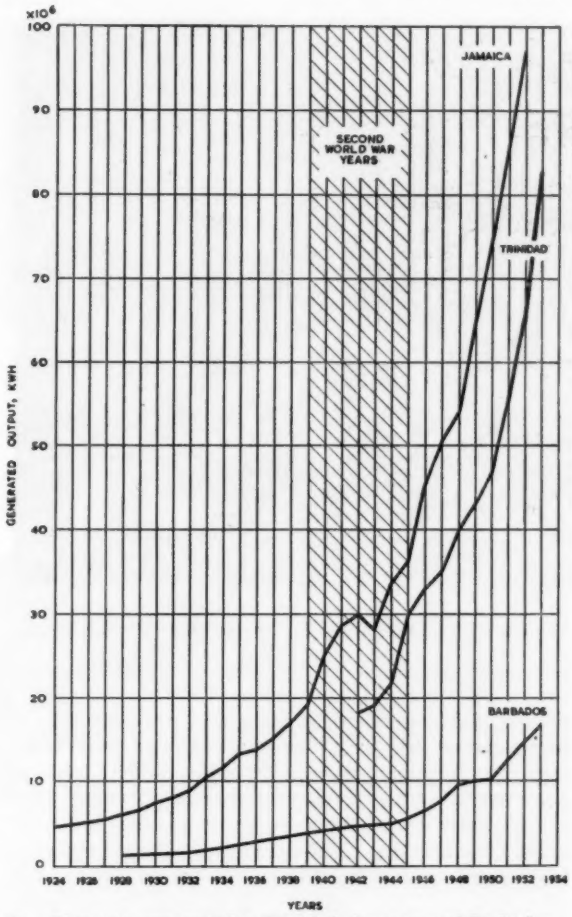
Statistics of Electricity Supplies

Electricity supplies were slowly developed over the years and, in general, kept pace with the demand, but the sudden industrial expansion has meant a rapid if somewhat difficult advance in the field of electricity supply and distribution. Fig. 2 illustrates the large increase, over the last few years, in electricity generated in just three of the islands, namely Trinidad, Jamaica and Barbados.

The approximate figures in the Table give some idea of the operation of the West Indian electricity undertakings in comparison with undertakings in the Isle of Wight. It will be seen that, with the exception of Bermuda, where almost one-third of the population are consumers and where the unit consumption per head is high, there is still room for vast expansion in order that electricity may benefit even a moderate percentage of the population of the islands listed. This state of affairs is typical of almost all other territories in the area, except the American-owned island of Puerto Rico.

American Influence

The conditions which obtain in Puerto Rico are unique,



2 *Electricity generated in Trinidad, Jamaica and Barbados*

Approximate Technical Statistics of various West Indian Supply Undertakings, compared with those of the Isle of Wight (April, 1954)

Place	Year	Population	Consumers	Consumers/population ratio	Annual generated energy	Maximum demand	Load factor	Energy/head	Energy/consumer	Maximum demand/consumer
				%	kWh × 10⁶	kW	%	kWh	kWh	watts
Barbados ..	1951	215 000	7 830	3·6	12·5	2 730	52·0	58	1 596	349
	1952	215 000	8 360	3·9	14·72	2 930	57·5	68·5	1 760	350
	1953	215 000	8 500	4·0	16·49	3 400	55·5	77·0	1 940	400
Jamaica ..	1951	1 429 000	25 000	1·7	86	15 940	61·5	60	3 440	637
	1952	1 429 000	29 066	2·0	97	18 320	60·4	68	3 350	663
Trinidad ..	1951	586 000	14 586	2·5	53·3	11 250	56·1	94	3 791	771
	1952	649 000	17 053	2·6	65·1	14 240	52·0	100	3 817	835
	1953	669 000	21 018	3·1	82·9	17 500	54·1	124	3 944	833
Bahamas ..	1951	81 000	6 677	8·2	18·5	4 100	51·5	230	2 770	614
Bermuda ..	1951	35 000	11 066	32·0	40·63	9 200	50·4	1 160	3 670	831
St. Vincent ..	1951	62 000	1 236	2·0	0·8	165	55·0	129	647	134
Isle of Wight ..	1951	86 000	27 000	31·0	56·4	15 940	40·5	655	2 088	590

3 *The Water-Street fire of 1952 (Georgetown, British Guiana)*

for the higher standard of living and prosperity of the island undoubtedly exist because it is United States territory. Tariff barriers between it and the United States are non-existent, so that goods manufactured in Puerto Rico at a relatively low labour cost enjoy an immediate market in the United States. This island is also one of the main sources of sugar consumed in the United States, and much American capital has been expended in introducing the most modern methods of production.

Perhaps, rather naturally, the American influence in other islands is most marked in the north, where they are nearest to the mainland of the United States, and there it is usual practice to provide electrical installations which comply with the standards of the United States or the Canadian National Code of Wiring Regulations. In the south the authorities, while accepting many American and Canadian standards, are more disposed to adopt the Wiring Regulations of The Institution.

The post-war restriction of expenditure in the dollar countries has meant an increase in the use of electrical materials from Great Britain, but as the value of the pound relative to the dollar rises, the situation is again slowly changing in favour of Canada and America.

Wiring Standards

Far too little emphasis is, however, laid upon the vital importance of ensuring satisfactory wiring standards, so that, with buildings that are largely constructed of timber, great havoc has been wrought by fires, which are often started as a result of poor electrical installations. The specific cause of such fires is always difficult to establish, and in Georgetown, British Guiana, for example, two separate fires of great magnitude, the specific causes of which were problematical, have destroyed whole sections of the town. Fig. 3 illustrates the aftermath of the last of these fires, which occurred as recently as 1952.

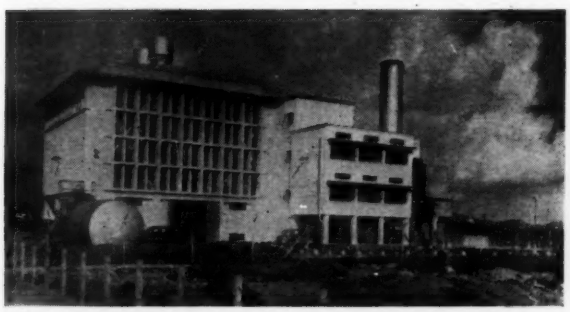
In the autumn of 1954 a serious fire destroyed a part of the shopping centre in Nassau, and it would seem that great attention towards every precaution to limit fire risks is still necessary.

4 *University College of the West Indies, Jamaica*

Technical Training

The Governments of the islands, in consultation with the Colonial Office, The Institution, and those interested in the promotion of good electrical standards in the West Indies, have done much in recent years to improve such standards, including the training of West Indian engineers in Britain. It is perhaps only natural, however, that the West Indians are developing an increasing determination to become self-sufficient and to train their own administrators and technicians, with the perhaps unfortunate result that there is sometimes a tendency to resent the employment of those from Britain who have done much to help them towards their ends.

Higher education in the West Indies is centred on the new University College of the West Indies at Mona, which is situated in the hills surrounding Kingston, Jamaica (Fig. 4). Although this university is a very young one, having been completed only a little over a year ago, it has provided the means of giving higher education to a large number of West Indians, who through financial or other reasons would be unable to obtain it in Britain, the United States or Canada.



5 *The Hunts Bay Power Station at Kingston, Jamaica*

6 *The Penal Power Station in Trinidad*

Generating Capacity

Expansion in electrical generating capacity has been one of the greatest problems in the West Indies, and although much has been achieved towards alleviating the shortage of plant, there is still plenty to be done. In Jamaica the 4 750 kW hydro-electric station on the Lower White River came into service in 1952, while in 1953 the 10 000 kW steam station at Hunts Bay (Fig. 5) on the outskirts of Kingston provided a further and much needed addition to the island's electrical resources. The latter station has provision for additional plant, of capacity 10 000 kW, which is planned for completion in 1955.

In Trinidad, the first 5 000 kW set at the new Penal power station (Fig. 6) went on load in 1953. This station operates on natural gas, which is piped through a mile-and-a-half-long pipeline, laid to connect the power station with the Penal field of United British Oilfields of Trinidad Ltd. A further 5 000 kW set is at present being installed in this station, and plans are laid for increasing its capacity still more.

In Tobago, the Robinson Crusoe island to the north of Trinidad, a public supply of electricity was given for the first time in 1952 from a Diesel station of 270 kW, and it is interesting to learn that research is going on in conjunction with the British Electrical and Allied Industries Research Association to investigate the possibility of wind-power generation for Tobago. It has been established that the wind velocity averages 8 m.p.h., with a maximum of 30 m.p.h.

There are other new stations such as the hydro-electric scheme on St. Vincent, while many additions and improvements have been made to existing ones, but there is still an urgent necessity for improved facilities in many of the islands. In Barbados, for example, the situation is

7 *New buildings in Georgetown, British Guiana*

particularly acute, and it is encouraging to know that this is a matter now under urgent consideration.

New Installations

It is only during the last few years that building construction in the West Indies has followed our standards and those of the United States, for cement and steel were expensive rarities prior to 1939, while timber was cheap and plentiful. British architects, encouraged by a few pioneers of modern building construction and assisted to some extent by fires, earthquakes and hurricanes, have now convinced the West Indian peoples of the value of this more modern form of building construction. Many fine buildings, comparable with those in any part of the world, have risen from the ashes of those destroyed by fire, decayed through age and termites, or blown down by the hurricanes which are prevalent in the more northerly islands during the month of September. A typical example of this type of modern building is illustrated in Fig. 7.

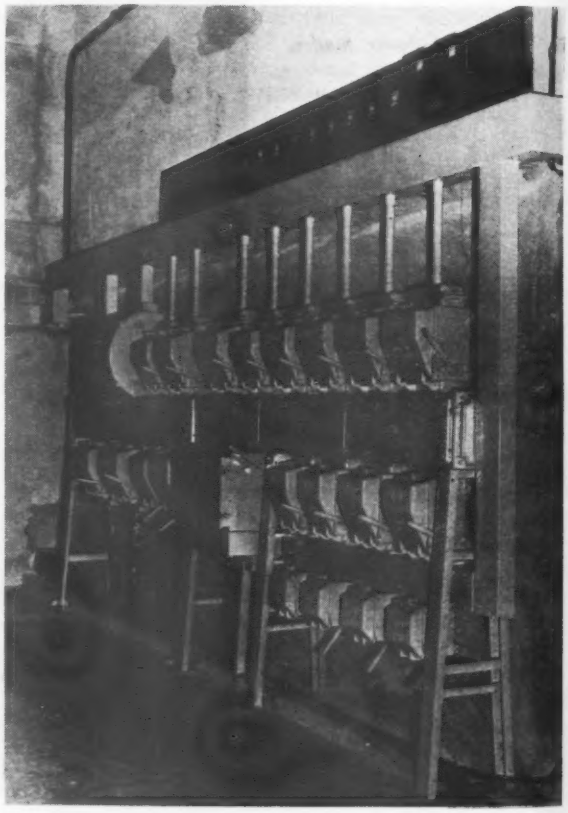
These buildings are situated in the shopping centre of Georgetown and replace those wooden buildings which were gutted in the disastrous fire of 1946. Electrical installations in these new buildings are extremely modern as will be seen from Fig. 8, showing the main switchboard installed in the General Post Office, which is the building with the tower on the left of Fig. 7.

Acknowledgments

I should like to accord my grateful thanks and acknowledgments to those who have so kindly supplied me with information and photographs, and in particular to: Mr. Philip H. Sutton; Mr. Kenneth W. Finch; Ewbank and Partners Ltd.; Watkins Gray and Partners; Mence and Moore; Norman and Dawbarn; Barlow and Young Ltd.

I would also take this opportunity of recording my thanks to those members of The Institution and other friends in the West Indies who have invariably extended to me great kindness and hospitality during the many visits I have paid to them.

8 *Main electrical switchboard at the General Post Office in Georgetown, British Guiana*



CORRESPONDENCE

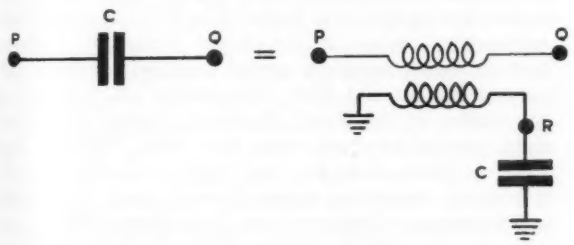
LETTERS TO THE JOURNAL ON ELECTRICAL ENGINEERING SCIENCE OR TECHNOLOGY ARE WELCOME. IN PARTICULAR MEMBERS (AND OTHER AUTHORS) WHO ARE SUBMITTING A PAPER TO THE INSTITUTION ARE ASKED TO CONSIDER THE POSSIBILITY OF MAKING A BRIEF PRELIMINARY ANNOUNCEMENT BY MEANS OF A LETTER BEFORE THE PAPER IS WRITTEN. CORRESPONDENCE SHOULD BE ADDRESSED TO THE SECRETARY OF THE INSTITUTION AND MARKED "FOR PUBLICATION." A CARBON COPY OF EACH LETTER SHOULD BE INCLUDED.

The Mechanism Analogous to a Circuit

From G. C. TOOTILL, M.A., M.Sc., *Associate Member*

Two analogies possible between mechanisms and circuits are described by Bloch[1,2] who points out that the "direct analogy," where velocity corresponds to voltage, and couple (or force) corresponds to current, gives topological identity between mechanical and electrical schematics.

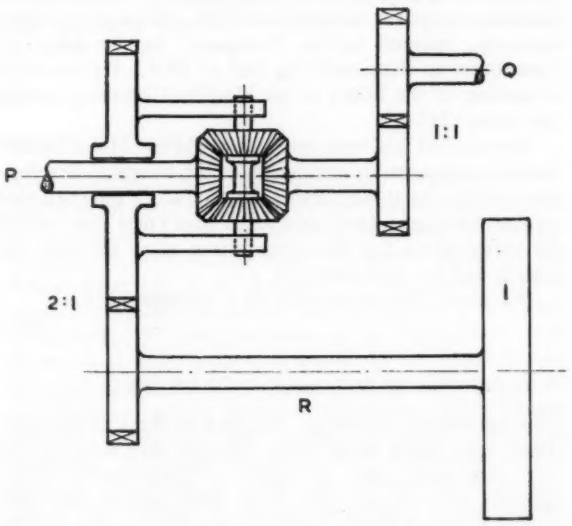
The clarity of the direct analogy shows up a difficulty which, in fact, has its counterpart in the "inverse analogy" (electromotive force corresponding to mechanical force



1 *Use of an ideal transformer to permit one terminal of a capacitor to be earthed*

or couple), but is obscured by the major difficulty of topological duality. In the direct analogy, compliance corresponds to inductance, and inertia or mass corresponds to capacitance between the point in question and earth. An electric circuit may include a capacitor that has neither of its terminals earthed. When the circuit is translated into a mechanism the element analogous to the capacitor is not simply an inertia, since this has only one mechanical "terminal," or, if another is postulated, it must be thought of as being connected to the stationary framework.

An ideal transformer of unit turns ratio may be used to permit one terminal of the capacitor to be earthed; and the capacitor itself then possesses its normal analogue (Fig. 1). A mechanism which has properties analogous to the ideal transformer with one terminal earthed is an ideal differential gear,* without friction, compliance, inertia or backlash. This drives the inertia (*I*) corresponding to the capacitor C, as shown in Fig. 2. Here, the couple transmitted from shaft P to shaft Q is proportional to the rate of change of the difference between the speeds of the two shafts, exactly as the current flowing from terminal P of the capacitor to terminal Q is proportional to the rate of change of the difference



2 *Mechanical analogue of Fig. 1*

between the voltages of the two terminals. If linear motion is used instead of rotary motion, a suitable arrangement of levers can be devised.

Although the analogue shown is probably of greater theoretical than practical use, it is worth pointing out that it holds at all frequencies, however low.

(1) BLOCH, A.: "Electromechanical Analogies and Their Use for the Analysis of Mechanical and Electrical Systems," *Journal I.E.E.*, 1945, **92**, Part I, p. 157.

(2) BLOCH, A.: "On Methods for the Construction of Networks Dual to Non-Planar Networks," *Proceedings of the Physical Society*, 1946, **58**, p. 677.

* Cf. MAXWELL, J. C.: "A Treatise on Electricity and Magnetism" (Clarendon Press, 1904), 2, 3rd Edition, Part IV, Chapter VII.

Mr. Tootill is at the Royal Military College of Science.

OBITUARY

CHRISTIAN VILHELM GUNDORPH ALBERTUS

Christian Vilhelm Gundorph Albertus, R. af Dbg., who died on the 29th March, 1954, was born on the 15th August, 1874, and received his general education at Frederiksborg School, Hillerød.

He joined the Great Northern Telegraph Co. of Denmark as a telegraphist in 1892 and served for five years at the Company's stations in Newcastle upon Tyne, in Gothenburg, Sweden, and in Nystad, Finland. In 1897 he was transferred to the Technical Department of the Company's head office in Copenhagen as Assistant Engineer, and at the same time studied mathematics and engineering privately and through evening classes. He rose steadily in the Company, becoming in 1911 Chief of the Engineering Department at the head office. In 1916 he was appointed Engineer-in-Chief, a position he held with distinction until his retirement in 1936. His services were, however, retained by the Company, for he acted as Consultant to them until the end of 1944. He was also a member of the Board of the Holding Company during the years 1937–40.

Throughout his long and active career Mr. Albertus made a substantial contribution to the technical development of the Great Northern Telegraph Co.'s international communication system, and to all who knew him he will be remembered for his never-failing sense of duty, his energy and his high integrity.

He joined The Institution as a Member in 1917.

H. J.

CHARLES WILLIAM EMANUEL

Charles William Emanuel, who died on the 15th October, 1954, after being ill for some months, was born on the 18th February, 1896. A native of Cockermouth, Cumberland, he was educated at St. Bees School, and later was a Faraday House student. He served in a searchlight unit of the Royal Engineers throughout the 1914–18 War. He entered the electricity supply industry in 1920 and held appointments at Hendon, later becoming Deputy Mains Superintendent at Watford. In 1936 he succeeded the late Mr. A. Parker as Borough Electrical Engineer and Manager to the Workington Corporation, holding this post until 1946, when he was appointed as Manager of the Sutton Area of the London and Home Counties Joint Electricity Authority; after the nationalization of the supply industry he became Manager of the Sutton District of the South Eastern Electricity Board. During his term of office at Workington he planned and inaugurated the introduction of electricity distribution at 11 kV; this was intended to supersede the existing 3·3 kV system, which, by 1938, was unable to deal with the increased load. A start was made in 1939, and a portion of the system was completed in the period 1939–42 until restrictions imposed by the war curtailed the progress. Unfortunately Mr. Emanuel did not see his plans completed before he moved to Sutton, but the pattern of his proposals has, in the main, been continued by his successors.

He was a Freemason and a Rotarian, and his genial manner and happy disposition will be long remembered by his numerous friends, many of whom he made during his stay in Workington. He made frequent visits to the town in the years which followed and always took a keen interest in its affairs and those of the Lake District. He is survived by his widow and two daughters.

He joined The Institution as a Student in 1920 and was elected an Associate Member in 1922 and a Member in 1947.

L. S. W.

GEORGE EDWARD GRACE

George Edward Grace, who died suddenly on the 24th November, 1954, was born on the 22nd August, 1899, and was educated at St. Paul's, Dublin. After service during the First World War he took a full-time engineering course at the Royal Technical College, Salford, before serving a special engineering apprenticeship at Mather and Platt, Manchester, and continuing his studies at the Royal Technical College part-time. Subsequently he spent three years with Reyrolle and Co., Hebburn-on-Tyne, on work connected with automatic control of power stations, and four years as Switchgear Designer with Brookhirst Switchgear, Chester. In 1932 he became Senior Lecturer in Electrical Engineering at the Municipal Technical College, Bolton, where he was responsible for the teaching of electrical engineering throughout the College. During this stay in the North-West Mr. Grace gave valuable service to the Union of Lancashire and Cheshire Institutes on several engineering committees, and took an active part in the activities of the North-Western Centre of The Institution. Like so many other teachers in technical colleges, he gave himself whole-heartedly, during the period 1940–45, to the training of Service personnel, in addition to carrying out his normal civilian technical college duties. This additional strain may have contributed towards his comparatively early death.

He joined the staff of the College of Technology, Art and Commerce, Oxford, as Senior Lecturer in September, 1943, where he remained until his death. He was instrumental in building up, from very small beginnings, an effective and live electrical section of the Engineering Department. He was responsible for the planning of the electrical engineering laboratories in the first stage of the construction of the new technical college in Oxford, which is now nearing completion.

Throughout his teaching career, Mr. Grace used to the full his qualities of hard work, attention to detail, and interest in the individual welfare of his students, in conjunction with his sound practical abilities and engineering knowledge. His personal example inspired many students to success. He is survived by his widow.

Mr. Grace joined The Institution as an Associate Member in 1930 and was elected a Member in 1945.

H. L. H.

ROGER ERNEST GRIME

Roger Ernest Grime, M.Sc., who died on the 2nd November, 1954, at Lytham St. Anne's, was born on the 28th September, 1884, at Darwen, Lancashire. He started work at an early age, but gained a scholarship to Owen's College, Manchester, and obtained his B.Sc. in 1904. After leaving Owen's College, he entered the Electrical Department of Mather and Platt, Manchester. He remained with this Company throughout his career, which terminated as the result of two slight paralytic seizures. He took his M.Sc. degree at Manchester in 1907.

After several years gaining knowledge in the making and testing of electrical machinery, he became Chief Assistant Electrical Designer, and in 1914 was appointed Chief Electrical Designer of the Company. This was a position for which his training, experience and nature made him eminently suited. In this capacity he was responsible for all types of a.c. and d.c. machines, and his large d.c. generators and motors, as well as his rotary convertors, enjoyed a very high reputation. Main propelling motors designed by him were operating in every type of British submarine built during the 1914–18 War. In 1932 he became Chief Engineer in Mather and Platt's Electrical Department and he occupied that position until he retired in 1951.

He had a sound and wide scientific knowledge and was very thorough and painstaking in everything he took in hand. For more than 20 years he was an active and valuable member of many technical committees of the British Electrical and Allied Manufacturers' Association and of the British Standards Institution. He was concerned particularly with the development and establishment of Standards in connection with flameproof motors and enclosures.

Roger Grime was a modest and lovable character and a most loyal colleague. He had lived at Lytham St. Anne's since his retirement. He is survived by his widow.

He joined The Institution as a Student in 1908 and was elected an Associate Member in 1912 and a Member in 1927.

H. T.

GEORGE GILBERT JOBBINS

George Gilbert Jobbins, who died on the 9th October, 1954, was born on the 15th August, 1878. He was a pioneer of electricity distribution in Australia, and served for 54 years in the electricity supply organizations of Victoria. Mr. Jobbins was Engineer and Manager of the Melbourne Electric Supply Company's undertaking in Melbourne and Geelong, and when that company was transferred to the State Electricity Commission of Victoria in 1930, he became Engineer and Manager of the Commission's Electricity Supply Department. In December, 1937, he was appointed Chairman of the Commission, and retired from the Chairmanship in 1949. Mr. Jobbins was appointed Oversea Representative of The Institution in Victoria and Tasmania on the retirement of Mr. H. R. Harper in 1947. He was also Chairman of the Victoria and Tasmania Committee of The Institution from 1948 to 1952. He was a foundation member of The Institution of Engineers, Australia. For three years he was President of the Electrical Association of Victoria. He was a member of several leading clubs, including the Wallaby Club. After his retirement from the State Electricity Commission he became a director of several companies, including the Capel Court Group of Investment Companies.

He joined The Institution as an Associate in 1900 and was elected an Associate Member in 1909 and a Member in 1918.

C. A. P. O.

HENRY NIMMO

Henry Nimmo, C.B.E., who died on the 25th October, 1954, was born on the 25th July, 1885, and educated and trained as an engineer at various schools, including Coatbridge Technical School, in Scotland. He also received private tuition from Mr. J. M. Lowson for two years. At the age of 24 he joined the Irrawaddy Flotilla Co. of Rangoon as Electrical Engineer and began an association with Burma that was to have a profound influence on his subsequent career. After five years in Burma, which included two years as Assistant Engineer of the Rangoon Electric Tramways and Supply Company, he was appointed Electrical Engineer and Inspector to the Burmese Government. He came home in 1915 and joined the London Electrical Engineers, rising to the rank of Captain and serving in searchlight companies of the London A.A. defences. After a period at the end of the war as a District Education Officer in the Army, he returned to Burma in 1919 to his previous Government position with added duties as Officer-in-Charge, Burma Hydro-Electric Survey. He continued his military interests and held the rank of Major in the Rangoon Electrical and Mechanical Company of the Royal Engineers.

Mr. Nimmo's knowledge and experience eminently fitted him for the position of Chief Engineering Inspector of the Electricity Commission, to which he was appointed when on leave in 1929. He was made an Electricity Commissioner in 1945, and in 1948 became Chairman of the Southern Electricity Board. Early in 1954 he paid a short visit to Burma as a member of the Board of Trade industrial delegation.

His interests were wide and he led an active life, particularly in professional circles. He served for three years on the Council of The Institution and he was Honorary Treasurer from 1949 to 1952. He was for several years a member of the Examinations and the Oversea Committees of The Institution and was a Governor of the Benevolent Fund from 1947 to 1952. He had been President of the Engineers' Guild, the Association of Supervising Electrical Engineers and the Batti-Wallahs Society, besides serving on the councils of a number of electrical associations; and he was well known among electrical engineers on the Continent. He was made a C.B.E. in 1953.

He fell ill soon after his return from Brazil, where he had been attending the plenary meeting of the World Power Conference, and this illness led to his death. He was a delightful colleague, not given to wasting words, highly efficient and sincere in all he did. His death was keenly felt by his numerous friends, many of whom filled the Queen's Chapel of the Savoy to pay a tribute to his memory at a memorial service held there on the 4th November, 1954. He is survived by his widow and two daughters.

He joined The Institution as an Associate Member in 1911 and was elected a Member in 1920. He was also a Member of The Institution of Civil Engineers and of The Institution of Mechanical Engineers. C. G. M. N.

HUBERT WILLIAM WALKER

Hubert William Walker, who died on the 11th November, 1954, was born on the 27th June, 1884. He received his electrical engineering training at the Northampton Institute, London, and at Armstrong College, Newcastle upon Tyne. His practical training was obtained in installation work in Lowestoft and Hampstead from 1899 to 1909. In 1909 he became a junior assistant engineer in the Newcastle upon Tyne Electric Supply Co., and he served with this Company until 1913, obtaining experience in the construction, running and maintenance of many power stations and substations in the Tyneside district.

In 1913 Mr. Walker obtained a position as Electrical Engineering Surveyor for the National Boiler and General Insurance Co., and was stationed in the Sheffield area for 22 years; in 1929 he was Chairman of the Sheffield Sub-Centre of The Institution. He was transferred by the Company in 1935 to a similar appointment in the Oxford area, where he remained until he retired in 1946. He was always energetic and lively, with a keen sense of humour and had a great interest in his profession.

After retirement he worked very hard as a landowner, improving the farms and property which he had acquired while in the Oxford district. He is survived by his widow and two sons.

He joined The Institution as an Associate Member in 1919 and was elected a Member in 1945. H. S. R.

JOHN WEBB

John Webb, C.M.G., C.B.E., M.C., who died in Southern Rhodesia on the 12th October, 1954, was born on the 15th October, 1883. He obtained his early education at the East London College, and the Northampton and Regent Street Polytechnics. In the Boer War he served with the Imperial Yeomanry. On his return to England he was employed in the engineering section of the National Telephone Co. until the State took it over, when he entered the Post Office as Exchange Manager, subsequently becoming Traffic Superintendent, Class 1. His interest in automatic exchanges began early, and he was the Manager of the Croydon Area when Epsom Automatic Exchange, the first in England, was opened. Later he became a member of the London Telephone Committee dealing with the conversion of the London system to automatic working, and took an active part in the organization of the conversion of the Holborn area in 1927, when the director system, now widely used, was first adopted.

During the First World War, Mr. Webb served with the Royal Engineers in France, reaching the rank of Captain and gaining the Military Cross. He returned to the Post Office in 1919. In 1930 he was seconded to the Egyptian State Telegraphs and Telephones Administration as Traffic Manager; at that time they were modernizing their services throughout the country. Within a year he became Inspector General, a post which he held until his retirement nearly 17 years later. During this period he controlled a staff of some 12 000, and the number of telephone subscribers increased from 29 000 to 56 000, while the annual revenue increased from £688 000 to over £2 750 000. Under his able leadership automatic working was introduced in the larger cities and towns, and the trunk, radio and telegraph services were greatly extended; in addition, broadcasting services were established.

Mr. Webb organized and presided over the International Telecommunications Conference held in Cairo in 1938. He was made a Grand Officer of the Order of the Nile, and also received decorations from other Middle East countries.

During the Second World War his work was increased greatly by the military operations in the Middle East, in which the Egyptian State Telephones and Telegraphs Administration played an important part in providing the fixed communications so vital to the Services. His duties included those of Chief Communications Censor in Cairo; in 1941 he was made a C.B.E., and in 1944 a C.M.G.

He was a man of wide experience, outstanding personality and great charm, and he endeared himself to all his staff. A keen and indefatigable worker, he was interested in all the phases of his work and no detail was too small to engage his attention.

Mr. Webb joined The Institution as an Associate Member in 1939 and was elected a Member in 1943.

E. J. P.

MONOGRAPHS AND PAPERS
published separately this month

Separate Monographs and reprints of all papers published in the Proceedings are available at the price of 1s. 3d. each (post free). The inclusive charge for a copy of a paper allocated for reading at a meeting on separate publication and for a reprint of the paper and discussion (as published in the Proceedings) is 2s. 6d. (post free). This charge is made whether or not the reprint is required, but a reprint alone costs 1s. 3d., as noted above. However, separate copies of a paper allocated for reading are supplied free of charge 10 days before the first meeting at which the paper is to be read, whether in London or in the provinces. If a reprint also is required, a remittance should accompany the request. Reprints of a paper being read at a meeting cannot be issued before the paper and discussion have been published in the Proceedings, but they should preferably be ordered before or shortly after the paper has been read in London.

In an order, a Monograph or a paper can be specified completely by the author's surname and the serial number of the paper. Those who wish to avoid making a separate payment for each Monograph, paper, or reprint which they require can obtain books of voucher labels, price 10s. each, containing 8 vouchers, on application to the Secretary.

A list of papers published in the February issue of Part A of the Proceedings appears under "Contents of the Current Issues of the Proceedings" on page 135, and the serial number of each paper and the month of publication of a digest in the Journal is included. Synopses of both Monographs and papers which will be published separately before the next issue of the Journal appear below, and unless otherwise stated, their date of publication is the same as this issue of the Journal. Monographs will be republished in Part C of the Proceedings, and the relevant Part for the republication of a paper is given after the serial number of the paper.

MONOGRAPH

D. G. TUCKER, D.Sc., Ph.D.

Signal/Noise Performance of Multiplier (or Correlation) and Addition (or Integrating) Types of Detector

MONOGRAPH No. 120 R

An analysis is made, and numerical results are tabulated, of the processes of addition and multiplication of pulse signals against random-noise backgrounds. These processes may be carried out on the input signals, in which case coincidence in time and phase of the signals is required, or on the signals after they have been rectified and smoothed (i.e. on the envelopes), in which case coincidence is required only in time. If the backgrounds are uncorrelated with one another, the addition or multiplication of two or more scans together results in an increase in detectability of the signal. It is shown that, in general, multiplication is not much more advantageous than addition from the point of view of signal/noise ratios, and, as it is more difficult to perform in practice, it cannot be universally recommended.

Some subjective evidence is brought forward to show that the signal/noise detectability criteria used in the paper may well be closely and uniquely related to probabilities of detection. This result, if proved, would be of the greatest importance, since signal/noise criteria are much more easily calculated than probabilities of detection.

A digest of the Monograph will be published in Part B of the *Proceedings*.

PAPERS

Professor F. BRAILSFORD, Ph.D., Wh.Sc., and C. G. BRADSHAW, B.Eng.

Iron Losses at High Magnetic Flux Densities in Electrical Sheet Metals

PAPER No. 1794 M; PART A

The paper will be published on the 19th February.

A thermal method of measuring iron losses in sheet materials which may be used at any flux density is described. The method is used to measure the total iron losses at 50c/s in a number of silicon-iron materials and in one sample of cobalt-iron up to an approximate induction of $B_{max} = 2{\cdot}4\,\text{Wb/m}^2$. The hysteresis component of the loss, obtained by subtracting the calculated eddy-current loss, is found in all materials to reach a saturation value at high flux densities. Empirical formulae are given which aim at providing the loss at high values of induction from a knowledge of the losses at lower values only.

G. L. E. METZ

The Electrical Engineering Industry in the Post-War Economy —II

PAPER No. 1795; PARTS A AND B.

The paper will be published on the 21st February.

A paper given before The Institution in 1946 summarized statistics relating to the electrical engineering industry, its production, exports, and employment of labour, and attempted to show how the electrical industry compares with the broad pattern of industry in the United Kingdom.

The present paper reviews and brings up to date the information given in the first paper and attempts to outline the responsibilities of the electrical engineer in the social and economic spheres. It points out that the industry holds the key to increased productivity, not only in its own sphere of production, but in almost every other industry and that it has almost limitless possibilities for expansion.

It shows how the production of electrical plant, equipment and appliances has gone racing ahead of many other industries and is still increasing faster than the national income—a clear indication that electrical power and labour-saving devices are taking a much greater part in everyday life. It also shows that the United Kingdom's share of world trade is falling and is likely to continue doing so, and suggests that there is a danger of things going wrong owing to failure to make the best of the resources available to the industry.

P. E. AXON, O.B.E., M.Sc., Ph.D., C. L. S. GILFORD, M.Sc., and D. E. L. SHORTER, B.Sc.(Eng.)

Artificial Reverberation

PAPER No. 1796 R; PART B

The paper will be published on the 28th February.

The demand for a source of artificial reverberation in sound

transmission systems is commonly met by the use of reverberation rooms, but attempts have been made to fulfil the requirements by devices involving the transmission of the signal through a number of delay channels. The design and operation of such devices can be treated by simple theory, but in the present state of the art, the quality of artificial reverberation, like that of the natural product, cannot be completely assessed except by ear.

The paper discusses the characteristics of artificial-reverberation apparatus employing delay channels with overall feedback, and they are illustrated by the results of early experiments using acoustic delay tubes. The acoustic-tube system, while simple in principle, involves in practice much instrumental complication, and it becomes uneconomic if good sound-quality and long reverberation time are required.

Artificial-reverberation apparatus employing a magnetic-recording delay system, which is free from the defects associated with the acoustic tube, is described. By means of an artifice involving the use of a double recording track, the effective number of delay paths is greatly increased, and a high standard of performance is thus attained. This equipment has been in regular use by the B.B.C. for two-and-a-half years.

Artificial-reverberation systems involving a finite number of delay paths tend to produce flutter effects when transmitting impulsive signals. Such effects can be mitigated by the use of a small auxiliary reverberation chamber. By temporarily transferring the signal to the ultrasonic frequency region, the required effect can be conveniently obtained with a small water-filled reverberation tank. Details are given in the paper of equipment of this type which has been designed for use with the magnetic-recording system referred to.

A. O. JOHNSON, B.Sc.Tech., and N. F. MARSH, M.A.

The Standardization of Retail Electricity Tariffs

PAPER NO. 1798 U; PART A

The paper will be published on the 7th March.

In the paper the authors aim to review retail electricity tariffs in those parts of Great Britain covered by the 14 Area Boards. The paper broadly considers: (*a*) the situation which confronted the British Electricity Authority and the Area Boards at vesting date; (*b*) how the tariff problem has been tackled; (*c*) the progress so far made in the introduction of standard tariffs; and (*d*) problems encountered in introducing standard tariffs.

Notes are included on tariffs in the North of Scotland and Northern Ireland, and brief references are made to salient points of comparable tariffs in some other European countries.

K. C. BOWEN, B.A.

Sources of Error in U-Adcock High-Frequency Direction-Finding

PAPER NO. 1810 R; PART B

The paper will be published on the 19th February.

It is well known that errors in h.f. direction-finding using U-Adcock systems arise from a number of independent causes. Experiments have been carried out to assess their relative importance, and statistical methods have been used to calculate the respective contributions to the total variance of error in a series of typical check-bearings on known transmitters. The variance component, normally attributed to wave interference errors, has been studied particularly.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH JANUARY, 1955

	No. of Contributors	£	s.	d.
£1 000 and over	6	6 000	0	0
£100 to <£1 000	29	6 386	3	0
£5 to <£100	734	8 157	14	4
£2 to <£5	1 762	4 924	4	7
Under £2	16 226	8 769	11	5
		£34 237	13	4

HONORARY MEMBER

At an Ordinary Meeting of The Institution on the 6th January, 1955, the President announced that the Council had elected to Honorary Membership of The Institution, **Mr. James Robert Beard, C.B.E., M.Sc. (President 1940–41).**

FARADAY MEDAL

At the Ordinary Meeting of The Institution on the 6th January, 1955, the President announced that the Council had made the Thirty-Third Award of the Faraday Medal to **Sir John Cockcroft, K.C.B., C.B.E., M.A., M.Sc.Tech., Ph.D., F.R.S., Member.**

HONOURS AND DISTINCTIONS CONFERRED ON MEMBERS

NEW YEAR HONOURS LIST

The names of the following members of The Institution were included in the New Year Honours and Distinctions conferred by Her Majesty:

BARON

Gridley, Sir Arnold B., K.B.E., M.P. (*Member*).

C.B.E.

Green, E. H. R., M.Sc. (*Member*).
Melling, C. T., M.Sc.Tech. (*Member*).
Smith, Professor C. Holt, M.Sc. (*Member*).
Watson, Alfred, B.Sc. (*Member*).

O.B.E.

Duckworth, H. (*Member*).
Matthewman, Professor T. H. (*Member*).
Nixon, Comdr.(L) W. I., R.N. (*Associate Member*).
Philip, P. (*Member*).
Roberts, V. W. M., B.Sc. (*Associate Member*).
Vowles, G. A. (*Member*).

M.B.E.

Peddle, H. L. (*Associate Member*).
Wasser, H. E. (*Associate Member*).

FIFTY YEARS OF MEMBERSHIP

The Council take much pleasure in placing on record the completion of fifty years of membership of The Institution by the members whose names appear below, who first became associated with The Institution in the year 1905.

Allen, W.
Allom, G. F.
Anderson, W. J. A.
Bosworth, H. W.
Brown, T. A.
Browning, W.
Bullman, H. C.
Bullpitt, K. D., M.C.
Carr, L. H. A., M.Sc.Tech.
Clayton, A. E., D.Sc.
Coates, W. A.
Cooper, R. G.
Dawson, B.
De Renzi, A. J. C.
Dowse, C. M.
Dyer, W. S.
Ewer, Col. G. G., D.S.O., T.D.
Faber, O., O.B.E., D.Sc.
Farrer, M.
Feltham, J. B.
Findlay, K. B.
Frost, P. B., B.Sc.(Eng.).
Goolding, C. L.
Green, F. W.
Grinsted, W. H., O.B.E.
Hall, J. R.
Hewitt, L. B.
Hobson, C. B.
Houston, R. H. F.
Howe, Professor G. W. O., D.Sc., LL.D.
Jones, F. G.
Jones, W. E.
Joyce, S. A.
Kemp, P., M.Sc.Tech.
Lepine, L. J.
Lewin, A.
Lobel, P.
Lorkin, W. L.
McKerlie, J.
Main, F. W.
Maling, A.
Mallinson, Col. G. G., T.D.
Mousley, Lieut.-Col. J. N., R.E., D.S.O.
Nayler, J. N.
Nelson, Sir George
Nuttall, R. A.
Parkinson, G. R. J.
Pearce, H., B.Sc.(Eng.).
Pearson, H. H.
Peck, J. S.
Pitts, W. A.
Price, W.
Purser-Fletcher, F., O.B.E.
Rayner, E. H., M.A., Sc.D.
Rose, G. S.
Savage, C. E.
Shaw, R.
Shore, A.
Simpson, S.
Smith, J. W.
Smith, S. G.
Suggate, Lieut.-Col. C. F. D., M.C.
Taylor, W. T.
Thorpe, W. B.
Tomlinson, Major, R.A.F.
Townshend, E. G.
Udall, C.
Visger, H.
Wadsworth, T., M.Sc.
Walker, B. P.
Walker, J. R.
Wheeler, J. W.
White, Sir Bruce G., K.B.E.
Wilkinson, J. W.
Wright, F. T., M.B.E.
Wright, R.
Yorke, W.

JUBILEE OF THE THERMIONIC VALVE

A date which will ever be remembered by communication and electronic engineers is the 16th November, 1904, when Professor J. A. Fleming applied for a patent for his diode. The Jubilee of that event was celebrated recently by The Institution at a special meeting, when there were three lectures on the genesis and development of the thermionic valve, and an exhibition of valves.

The lectures, by Sir Edward Appleton, Professor G. W. O. Howe and Dr. J. Thomson, are being published in the spring in book form, together with the opening address by the Lord President of the Council, an appreciation of Sir Ambrose Fleming and Lee de Forest by Capt. C. F. Booth, and a complete list of the exhibits, which ranged from Fleming's lamps and valves to travelling-wave tubes. The book contains about 48 pages of text and 32 pages of illustrations, the pages being of the same size as those of the *Journal*. The price (post free) is 9s. to the public, and 4s. to members of The Institution. The edition is limited, and orders should be placed with the Secretary now.

A short account of the Celebration, with digests of the lectures, will appear in a future issue of the *Journal*.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

Members who are unable to be present at a meeting, or who, if present, do not have an opportunity of speaking, may submit written contributions to the discussion, and these will be considered for publication in the *Proceedings*. This does not apply to Informal Meetings or Discussion Meetings.

We would also remind members that written contributions on papers published in the *Proceedings* without being read at meetings will be considered for publication.

Members should note that the Papers Committee have been obliged to set a limit of 500 words for contributions of either sort.

CONSTITUTIONS OF COMMITTEES, AND REPRESENTATIVES OF THE COUNCIL

The constitutions of the Local Centre Committees, and the names of the Council's Oversea Representatives and of their Representatives on other bodies (including the Council for Codes of Practice) will be found on pages 117–128.

ELECTIONS AND TRANSFERS

Particulars of 603 elections and 411 transfers approved by the Council will be found on pages 131–134.

SUPPLY SECTION

ANNUAL LECTURE, 23RD FEBRUARY, 1955

The Supply Section Annual Lecture will be delivered on the 23rd February, when the President of the Swedish State Power Board, Mr. Åke Rusck, will be speaking on *High-Voltage Transmission Developments in Sweden*. This Lecture will be of great interest to members of The Institution, and we expect that there will be a large attendance.

The Lecture will be followed by the first showing of a new film on the Gotland High-Voltage D.C. Transmission Scheme. The film, which will run for about 30 minutes, will have an English commentary.

VISIT TO HOLLAND, SEPTEMBER, 1955

The main Supply Section Visit this year will be held in Holland from the 8th to 12th September, and preliminary details have already been issued to members of the Section with the January *Journal*.

The visit will be centred on Amsterdam but will include a visit to Arnhem to see the K.E.M.A. Laboratories, the Garden of Remembrance, and Hoge Veluwe, a national park in which there is a museum containing a number of Van Gogh's paintings. In addition there will be a visit to Schiphol Airport and a water-bus tour of Amsterdam's canals.

Any members interested in taking part in this visit should send their names to the Secretary as soon as possible.

MEMBERS TRAVELLING TO AND FROM THE UNITED KINGDOM

Members visiting or taking up residence in the areas of any of the Oversea Branches, Oversea Committees or Joint Oversea Groups, which were listed on pages 60 and 61 of the January issue, are invited to apply to the Secretary of The Institution for a letter of introduction to the appropriate Honorary Secretary.

The Secretary will be obliged if members coming home from oversea will inform him of their addresses in this country, even if they do not desire a change of address to be recorded in the Institution register. This will enable him to advise such members of the various meetings, etc., of The Institution and its Local Centres, and, when occasion arises, to put them into touch with other members.

The Secretary will be pleased if those members from oversea who are able to visit the Institution premises will call upon him.

COMMUNICATIONS FROM OVERSEA MEMBERS

Oversea members are specially invited to submit, for publication in the *Proceedings*, written communications on papers read before The Institution or published in the *Proceedings* without being read. The contributor's country of residence will be indicated.

Copies of all papers read before The Institution are sent to each Oversea Representative of the Council for distribution to members likely to be in a position to submit communications.

SOUTH OF SCOTLAND ELECTRICITY BOARD

Under the Electricity Reorganization (Scotland) Act the South of Scotland Electricity Board will, from the 1st April, 1955, take over the functions of the two Scottish Area Electricity Boards, which are at present responsible for the distribution of electricity, and the functions in the South of Scotland of the British Electricity Authority, which is at present responsible for the generation and transmission of electricity.

It was announced in December, 1954, that the constitution of the new Board would be as follows:

Chairman: J. S. Pickles, B.Sc.Tech., Member.

Deputy Chairman: Sir Norman Duke, K.B.E., C.B., D.S.O., M.C.

Full-time Members: W. Hutton, M.A., LL.B., Companion.
W. S. Sawtell, Member.

Part-time Members: Col. J. G. Crabbe, O.B.E., M.C., J.P.
Sir John Imrie, C.B.E., M.A., B.Com., J.P.
Jackson Miller, C.B.E., D.L., J.P.
Bailie J. Sullivan.
Sir Ronald J. Thomson, V.L.

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

The Rt. Hon. T. Johnston, C.H., LL.D., Chairman of the North of Scotland Hydro-Electric Board, and Sir Hugh Mackenzie, C.B.E., Deputy Chairman of the Board, have recently been reappointed for further terms of office.

THE INSTITUTION BUILDING

A photographic portrait (in colour) of H.M. The Queen, the Patron of The Institution, has been hung in the Tea Room.

Changes are also taking place in the Common Room and the Tea Room, which are designed to enhance the appearance of these rooms. The rooms have been redecorated, and the remainder of the tungsten-filament lighting has been replaced by fluorescent lighting; plans are also in hand for improving the general furnishing of the rooms by the renewal of the chairs, settees and curtains, and the supply of new carpets. It is anticipated that this work will be completed before the end of the session. In addition, the names of the present and past Chairmen of each Specialized Section of The Institution are now displayed on boards in the Common Room. The changes will improve the comfort and appeal of these rooms and we think they will be appreciated by members.

INTERNATIONAL CONFERENCE ON ANALOGUE COMPUTING

With a view to ensuring better contacts between specialists in Analogue Computing, the Société Belge des Ingénieurs des Télécommunications et d'Électronique is organizing, with the help of the Société Belge des Électriciens and of the Société Belge des Mécaniciens, an International Conference on Analogue Computing; this will be held in Brussels from the 27th September to the 1st October, 1955. The programme of the Conference will cover the various analogue computing methods (differential analysers, current analogues, network analysers, simulators, special calculators) and their application to science and industry.

The Organizing Committee have invited a few eminent specialists to give one-hour lectures, in order to summarize the present status of various techniques of analogue computing. Short papers (lasting about 15 minutes each) on more special aspects will follow the introductory lectures. The official languages will be French and English. In addition to the lectures there will be an exhibition of equipment of interest to manufacturers and users of analogue machinery. The participation fee has not yet been fixed, but it will not exceed 150 Belgian francs for the authors of papers and 300 Belgian francs for other participants. The fee will entitle the subscriber to receive at the opening of the Conference a copy of the summaries of all lectures and papers, and, at a later date, a copy of the detailed report of the proceedings.

The Organizing Committee would like to know as soon as possible the names and addresses of those who intend taking part in the Conference, and whether they wish to submit papers or exhibit equipment. More detailed information concerning the programme and the actual organization of the meeting will be available shortly. All inquiries and correspondence should be addressed to Monsieur P. Germain, Institut de Physique appliquée, Université libre de Bruxelles, 50 avenue Franklin Roosevelt, Brussels.

A PORTRAIT OF EDWIN H. ARMSTRONG

The Union Internationale des Télécommunications have now published an etching of Edwin H. Armstrong in their series of portraits of pioneers in communication engineering. Prints of the portrait, which are reproduced on art paper and measure 23 × 17cm overall, can be obtained from the Secrétariat Général de l'Union Internationale des Télécommunications, Palais Wilson, 52 rue des Päquis, Geneva, price 3 Swiss francs (post free). The number of prints available is limited to 700. A small number of portraits of Ampère, Baudot, Bell, Erlang, Faraday, Ferrié, Gauss, Heaviside, Hertz, Hughes, Kelvin, Lorentz, Marconi, Maxwell, Morse, Popov, Pupin, Siemens, Tesla, and Weber are still available; the price of each portrait is 3 Swiss francs (post free).

some recent BOOKS

VERA CONNELL (*Compiler and Editor*)
THE APPLICATION OF RESULTS OF RESEARCH
BUTTERWORTHS SCIENTIFIC PUBLICATIONS. 212 PP. 21s.

This book originated from the British Commonwealth Scientific Official Conference in 1946, which requested a report on methods for promoting the utilization of non-patentable scientific and technical results. The report grew into a book, which as a compendium of information is most valuable. The factual information is collected in appendices that occupy all but some 40 pages of the volume and cover the United Kingdom, Canada, Australia, New Zealand, South Africa, India, Ceylon, and Rhodesia, with some notes for comparison on the methods of the Tennessee Valley Authority, the U.S. Department of Agriculture, the U.S. Research Corporation and the University Research Foundations. The author gives a short description of all the government and government-sponsored agencies which deal with the application of science in industry, including investigations on work study and organization, and on human efficiency and the repercussions thereon of physiological and psychological characteristics. These descriptions will be illuminating to those who have not hitherto had the time to acquaint themselves with the many organizations concerned and will be useful for reference to those who are more knowledgeable. Apart from the United States selection, which seems not very well chosen or even necessary, the main criticism of the book is that industry's own voluntary efforts receive very brief mention, confined almost entirely to the section on the United Kingdom, where such efforts preponderate. For this there is reasonable excuse in that the book is primarily concerned with government action and is particularly directed to the Commonwealth oversea, where government stimulus to development is more needed. There is less excuse for ignoring the professional and similar institutions, seeing that bodies such as the British Standards Institution are rightly included.

The first part of the book comprises a review of methods of disseminating scientific and technical information, observations on difficulties in applying the information, and the general conclusions of the British Commonwealth Scientific Conference of 1952 in Australia. The division of methods of dissemination into conventional and special is arbitrary; e.g. abstracting is conventional, and an information service is apparently special. Although there are useful discussions on a few topics such as the decentralization of information services, yet some are treated too cursorily or without appreciation of basic problems. The author mentions the economic difficulties of abstracting services, but not the problems of expert abstractors, coverage, user demands, and international co-operation, as occur, for example, with *Science Abstracts*. The chapter on obstacles to the assimilation of information says little that is new. The conclusions of the 1952 Conference are sound but rather too vague to be inspiring. Admittedly they purport mainly to summarize opinions there expressed which had already been given elsewhere at greater length. A great deal has been spoken and written on the application of science to industry: especially have there been many, sometimes not too well-informed, exhortations to Britain to do better. At this stage, therefore, it is a pity that a book which has so much in it that is both accurate and useful should miss the chance of vigorous and constructive comment.

R. L. MURRAY
INTRODUCTION TO NUCLEAR ENGINEERING
NEW YORK: PRENTICE-HALL. 418 PP. £3 15s.

The possibilities of producing useful power by nuclear fission are attracting world-wide attention, and engineers specially trained in nuclear technology are required on an increasing scale to man the many projects which are being initiated. In America this need is being met by special courses of training at the Oak Ridge National Laboratory at Tennessee, and by a number of university undergraduate and post-graduate courses in nuclear engineering which are now in operation. In Britain progress has not been quite so rapid, but already the United Kingdom Atomic Energy Authority has set up a reactor school at Harwell, and it seems likely that one or two, at least, of the British universities will not be slow to follow the example of their American counterparts. In Britain, however, the usual view is that nuclear engineering should be taught in a post-graduate course.

The need for training immediately raises a requirement for suitable textbooks, and already a number of such books have appeared. The present volume by Professor Murray is the third book on nuclear engineering to come into the reviewer's possession, and it gives a good introduction to the subject. It is written for the person with a background in the fundamentals of conventional engineering who wants a working understanding of nuclear physics and atomic energy in relation to practical problems. The scope of the book is very broad. Not only is there a full discussion of nuclear reactors, their design, construction, testing and operation, but there is much information on such related topics as the accumulation of nuclear fuel; the handling of radioactive material; the design of instruments for particle detection; the establishment of standards and practices in radiation protection; and the uses of isotopes for industrial and biological purposes.

Professor Murray is well qualified to write a book on nuclear engineering. He is Professor of Physics at the North Carolina State College of Agriculture and Engineering, where he teaches undergraduate and graduate courses in reactor theory and reactor design in the nuclear engineering programme. This is one of the few colleges to have a small experimental reactor for use in their practical classes. It is not surprising, therefore, that with this background and such facilities Professor Murray should have produced a clear and lucid account of the subject, and one that takes proper account of the difficulties of the young student with experience as an engineer, rather than as a nuclear physicist. The bulk of the book is concerned with the design and operation of nuclear reactors, separate chapters being included on: nuclear reactor principles; the water boiler (a homogeneous reactor, water-moderated and using enriched uranium as the fissionable material); reactor start-up and operation; the materials used in reactors; the principles of heat transfer and fluid flow as applied to reactor design; the design of a gas-cooled enriched-uranium reactor; the design of a liquid-metal-

cooled natural-uranium reactor; and detectors and control instruments. The treatment of the more advanced reactors is a little superficial, and the more knowledgeable reader may doubt whether the designs suggested are feasible. Nevertheless, within the present security restrictions, the author has done well to discuss such a wide range of subjects without introducing too many obscurities. In addition, there are separate chapters on the production of electric power from fissionable fuel, and the nuclear propulsion of aircraft, submarines and rockets. These do little more than indicate possibilities and outline some of the major problems, but here again security restrictions no doubt prevent a more adequate treatment of such problems.

The book is well printed and illustrated and can be recommended to those engineers who want an introduction to these new horizons.

LIBRARY ACCESSIONS

* *Denotes that the book is also in the Lending Library. The books cannot be purchased at The Institution; the names of the publishers and the prices are given only for the convenience of members.*

BOOKS

ANDÉ, F. 621.314.2

Betrieb und Anwendung Leistungs- und Regeltransformatoren [Operation and application of power and regulating transformers]

8vo. 319 pp. Berlin: Springer-Verlag, 1954. 33 Dm.

BASSERAS, G. 621.39(076)

Exercices et Problèmes de Radioélectricité à l'Usage de l'Ingénieur

4to. 263 pp. Paris: Éditions Léon Eyrolles, 1954. 2 250 frs.

BERANEK, L. L. 534.8

Acoustics

8vo. 481 pp. London: McGraw-Hill Publishing Co. Ltd., 1954. £3 4*s*. 6*d*. *

This is a modern treatment of the subject for college students, but the book is mainly concerned with electro-acoustics and in particular with transducers.

BOYD, R. L. F., and SEATON, M. J. (EDITORS) 629.135

Rocket Exploration of the Upper Atmosphere: Special Supplement (Vol. 1) to the *Journal of Atmospheric and Terrestrial Physics*

8vo. 376 pp. London: Pergamon Press Ltd., 1954. £3 15*s*.

The papers included in this volume were read at a conference arranged by the Upper Atmosphere Rocket Research Panel of the United States and by the Gassiot Committee of the Royal Society of London. They deal with rocket techniques; pressures, temperatures, winds and composition of the high atmosphere; the ionosphere, solar radiation, geomagnetic variations, and cosmic ray measurements; with laboratory studies, theoretical considerations and suggested experiments.

BROWN, F. (EDITOR) 058

Statistical Year-Book of the World Power Conference, No. 7. Annual statistics for 1950–1952, with some supplementary and revised statistics for earlier years and available statistics for 1953; some additional and revised data on resources

8vo. 160 pp. London: Lund, Humphries and Co. Ltd., 1954. £2.

Statistics, resources, production, stocks, imports, exports and consumption of power and power sources in various countries.

BÜTOW, W. 621.316.9

Relais und Schutzschaltungen in elektrischen Hochspannungsanlagen [Relays and protective circuits in high-voltage electrical installations]

8vo. 234 pp. Karlsruhe: Verlag G. Braun, 1954. 24 Dm. *

CABLE, J. W. 621.365.5

Induction and Dielectric Heating

8vo. 576 pp. New York: Reinhold Publishing Corporation, 1954. £5.

The first half of this book deals with induction heating, the second half with dielectric heating. In each case the theory and appropriate sources of energy and equipment are discussed. The book is chiefly concerned, however, with applications and these are discussed in detail.

CARR, T. H. 621.3(076)

Questions and Answers on Distribution and Use of Electric Power

Sm. 8vo. 112 pp. London: George Newnes Ltd., 1954. 6*s*. *

Questions which may arise during the course of the duties of works engineers, electrical contracting personnel, junior engineers, and students connected with the electrical supply industry. They have been selected from a wide field including cables, wiring, lighting, heating, sub-stations, batteries, induction motors, etc.

CARR, T. H. 621.3(076)

Questions and Answers on Power Station Practice and Plant

Sm. 8vo. 128 pp. London: George Newnes Ltd., 1954. 6*s*. *

This book is a companion to Questions and Answers on Distribution and Use of Electric Power. The questions relate principally to power station practice and plant.

CONNELL, V. (EDITOR) 001.8

The Application of Results of Research

8vo. 212 pp. London: Butterworths Scientific Publications, 1954. 21*s*. *

A report presented to the British Commonwealth Scientific Conference in 1952. It reviews existing methods of communicating the results of research including in particular abstracting services, information bureaux and industrial liaison officers. It refers in the conclusions to the need for organized technical developments to follow scientific research. Appendices review existing facilities in this and the other Commonwealth countries. The book is reviewed on page 111.

CROW, L. R. 621.318.42

Saturating Core Devices: operating principles and applications

8vo. 371 pp. Vincennes, Indiana: The Scientific Book Publishing Co., 1949. 34*s*. •

Describes in a very elementary manner the basic principles of the various types of saturable-core-reactor devices and the way these devices can be applied for control purposes and as magnetic amplifiers. Simple and clear diagrams are used extensively to aid the reader.

CROW, L. R. 611.313–181.4

Synchros Self-Synchronous Devices and Electrical Servo-Mechanisms

8vo. 222 pp. Vincennes, Indiana: The Scientific Book Publishing Co., 1953. 34*s*. •

Describes with the aid of numerous diagrams the principles of operation governing that class of control device and position indicators of which the Selsyn is a well-known example.

DOUGLAS, A. 681.8

The Electronic Musical Instrument Manual: a guide to theory and design

2nd ed. 8vo. 221 pp. London: Sir Isaac Pitman and Sons, Ltd. 1954. 30*s*. •

A considerable enlargement of the original edition in which greater attention is given to the production and mixing of valve oscillations. The details given cover the basic principles of every type of electronic musical instrument in production. The book contains many diagrams and pictures illustrating the electrical and mechanical features described, and a useful bibliography.

DOVER, A. T. 621.33

Electric Traction

3rd ed. 8vo. 441 pp. London: Sir Isaac Pitman and Sons, Ltd., 1954. £3. •

The author in preparing this new edition has achieved a remarkably concise work which covers every aspect of the subject, including the most recent developments. Besides dealing with fundamental principles this book contains much practical information and it is intended for both students and engineers. The book was reviewed in the Journal, January, 1955.

GARRETT, C. G. B. 536.483

Magnetic Cooling (Harvard Monographs in Applied Science No. 4)

8vo. 110 pp. Cambridge, Massachusetts: Harvard University Press, 1954. 36*s*. •

A survey of the most recent results of research into low-temperature paramagnetism and the application of magnetic cooling to investigations of the properties of materials under conditions of extreme cold—temperatures below 1° absolute.

The technique of magnetic cooling and methods of measurement of temperature and specific heat are described, and the thermodynamics of magnetization and the theory of paramagnetism discussed.

GOLDMAN, S. 621.392

Information Theory

8vo. 385 pp. New York: Prentice-Hall, Inc., 1953. £3 12*s*. •

Gives an explanation of the principles of information theory using the least complicated mathematics. In certain instances the mathematical development is consigned to the appendix together with the solutions to some of the problems. The book is based on the classical work of Shannon but it contains many results which the author believes to be new.

GRAY, T. S. 621.38

Applied Electronics: a first course in electronics, electron tubes, and associated circuits

2nd ed. 8vo. 881 pp. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1954. £3 12*s*. •

Deals first with the physics relevant to the subject—electron ballistics, electron emission from metals, electron conduction in vacuum and in gas-filled tubes. Then discusses the use of valves as rectifiers, amplifiers, oscillators and modulators. There is also a chapter on semi-conductors and transistors.

HUGHES, E. 621.31

Fundamentals of Electrical Engineering based on the Rationalized M.K.S. System of Units

8vo. 470 pp. London: Longmans, Green and Co., 1954. 12*s*. 6*d*.

This book is intended for students in the third year course for Ordinary National Certificate and those preparing for the Intermediate examinations of the City and Guilds of London Institute, and also for first-year degree students. Approved symbols and nomenclature have been adopted, and the rationalized M.K.S. system of units is used. Problems, with answers, are given at the end of each chapter.

JUDGE, A. W. 629.11:621.3

Automobile Electrical Maintenance

3rd ed. sm. 8vo. 256 pp. London: Sir Isaac Pitman and Sons, Ltd., 1954. 12*s*. 6*d*. •

A guide for service engineers and motorists. It illustrates the individual circuits which are combined into complete wiring systems. Describes and gives illustrations of the electrical components and accessories and discusses faults and their symptoms.

KAUFMAN, M., and THOMAS, H. 621.397.3

Introduction to Color T.V.

8vo. 140 pp. New York: John F. Rider Publisher, Inc., 1954. $2.10 •

A simple description of the principles of the system of colour television approved by the National Television System Committee. The method of operation of tricolour picture tubes is explained and the detailed circuit design of colour television receivers is illustrated by descriptions of two commercial receivers.

KENDALL, J. 92(DAVY)

Humphry Davy: "Pilot" of Penzance

8vo. 165 pp. London: Faber and Faber, 1954. 10*s*. 6*d*. •

This interesting biography is light reading, yet it gives a good picture of Davy's scientific work, his time at the Royal Institution and his association with Faraday. It deals too with his recreations, private life and the journey to France.

KRUGMAN, L. M. 621.314.63

Fundamentals of Transistors

8vo. 140 pp. New York: John F. Rider Publisher Inc., 1954. $2.70 •

Describes the basic physical theory of the germanium transistor, and the principles of operation of various types. Their behaviour and characteristics are compared with ordinary thermionic valves by considering them as four-terminal networks. Gain, impedance matching, inherent noise, harmonic distortion, frequency response and output power, and applications as amplifiers, oscillators, and in h.f. circuits, are discussed.

LOCKE, J. R. 621.397.3

Highlights of Color Television

8vo. 44 pp. New York: John F. Rider Publisher Inc., 1954. 99 c.

A very brief statement of the principles of the system of colour television approved by the National Television System Committee.

LONDON, F. 537.312.6

Superfluids: Volume 1. Macroscopic Theory of Superconductivity

8vo. 161 pp. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950. £2.

Reviews some properties of superconductors and their thermodynamical correlation. Discusses the electrodynamics of the pure superconducting state, the intermediate state, reconsiders the phase transition into the superconducting state and suggests a programme for the molecular theory of superconductivity.

MOLLOY, E. (EDITOR) 681.2

Chemical Engineering Instruments and Control Methods

8vo. 182 pp. London: George Newnes Ltd., 1954. 21*s*.

A practical guide for chemical engineers to the various types of meters used in control equipment in which each chapter is written by an experienced author. It deals with pH meters, colorimetry, moisture testing, spectrophotometry, the infra-red spectrometer, photo-electric instruments, the polarimeter, pressure and level indicators and ultrasonic equipment. There is a chapter on process control and one on the handling of radioactive materials.

MORISSET, P. 621.357.7

Chromium Plating

8vo. 586 pp. Teddington: Robert Draper Ltd., 1954. £3 18*s*. *

This is a comprehensive account of the theory and practice of the electro-deposition of chromium. Both hard chrome plating for industrial purposes and bright finishes for decorative purposes are fully dealt with.

MURRAY, R. L. 539

Introduction to Nuclear Engineering

8vo. 418 pp. New York: Prentice-Hall, Inc., 1954. £3 15*s*.

Based on a series of lectures to college students the theory of fission and chain reaction and the principles of reactors are first explained. Then the various aspects of a reactor plant are discussed—the water-boiler, the starting-up process, the materials of construction, reactor cooling and radiation hazards. Other chapters deal with applications, including the generation of electrical power—for which some comparative figures are given, and by-products. This book is reviewed on page 111.

NEWELL, H. E. 629.135

High Altitude Rocket Research

8vo. 298 pp. New York: Academic Press Inc., 1953. £3 *

The features of this book of particular interest to electrical engineers will be the details of developments in telemetering equipment and radio transmitters and recorders used for high altitude investigations. Two chapters deal with the ionosphere, the earth's magnetic field, and with the results of cosmic-ray research.

NOLL, E. M. 621.397.3

Color Television

4to. 46 pp. Indianapolis: Paul H. Wendel Publishing Co., Inc., 1951. 8*s*.

A brief practical description of American systems and the colour criteria of the Federal Communications Commission.

PATIN, P. 621.33

La Traction électrique et Diesel-électrique [Electric traction and diesel-electric traction]

8vo. 309 pp. Paris: Éditions Léon Eyrolles, 1954

PETERS, J. 621–52

Einschwingvorgänge Gegenkopplung, Stabilität theoretische Grundlagen und Anwendungen [Transient phenomena, feedback, stability; theoretical principles and applications]

8vo. 181 pp. Berlin: Springer-Verlag, 1954. 27 Dm.

This book was reviewed in the Journal, January, 1955.

REICH, H. J., AND OTHERS 621.396.029.6

Microwave Theory and Techniques

8vo. 901 pp. New York: D. Van Nostrand Company, Inc., 1953. £3 15*s*. *

The opening chapters deal with the theory of static and dynamic electromagnetic fields, and with a general consideration of antennas. Transmission lines, waveguides and the physical principles of microwave amplifiers and oscillators are discussed, and there is a detailed treatment of waveguide and coaxial line components, klystrons and magnetrons.

SAY, M. G. (EDITOR) 621.314.63

Crystal Rectifiers and Transistors

8vo. 170 pp. London: George Newnes Ltd., 1954. 21*s*. *

A survey of published information concerning the development of silicon and germanium crystal rectifiers and transistors.

SCROGGIE, M. G. 621.396

Radio Laboratory Handbook

8vo. 436 pp. London: Iliffe and Sons Ltd., 1954. *

A larger page size has been used for this edition so that although there are approximately the same number of pages the contents have been considerably extended. The chapter layout follows the previous pattern, but the information has been brought up to date wherever necessary.

SMITH, S. P. 621.3(076)

Problems in Electrical Engineering, with Answers

8vo. 342 pp. London: Constable and Co. Ltd., 1954. 18*s*. *

This edition contains over 1 800 problems covering first- to final-year studies of degree and Higher National Certificate students. The majority of the problems are now stated in M.K.S. and C.G.S. units and a conversion table for the more important quantities is also provided.

SPREADBURY, F. G. 621.43.04

Electrical Ignition Equipment

8vo. 227 pp. London: Constable and Co. Ltd., 1954. 25*s*. *

After some discussion of the theory of the ignition of explosive mixtures the author deals with the considerations involved in the design of sparking plugs, ignition coils, magnetos and complete ignition systems. The final chapter is on testing equipment.

STILL, A., and SISKIND, C. S. 621.313.04

Elements of Electrical Machine Design

3rd ed. 445 pp. New York and London: McGraw-Hill Book Co., Inc., 1954. £3 12*s*. *

A book for college students. Much of the general introductory theory has been omitted from this edition and the book now deals solely with the principles of rotating machines and transformers. Materials of construction and the effect of new materials on the design of machines are discussed.

TAYLOR, E. O. 538.551
Power System Transients
8vo. 176 pp. London: George Newnes Limited, 1954. 21*s.* •
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D. C. Fleming, B.Eng. (26.4.45)

SUB-COMMITTEE ON ELECTRICAL NOMENCLATURE AND SYMBOLS—TYPES OF ENCLOSURE (ELE/9/8)
S. J. Emerson (20.5.54)

SUB-COMMITTEE ON AUTOMATIC CHANGE-OVER SWITCHES FOR EMERGENCY LIGHTING SYSTEMS (ELE/10/16)
*E. J. Sutton (15.6.50)

SUB-COMMITTEE ON EARTH LEAKAGE CIRCUIT-BREAKERS (ELE/10/18)
*H. W. Grimmitt (13.5.48)
Further appointment pending

TECHNICAL COMMITTEE ON ELECTRICAL INSTRUMENTS (ELE/13)
R. B. Armstrong, B.Sc. (5.4.51)
J. F. Coales, O.B.E., M.A. (5.11.53)

TECHNICAL COMMITTEE ON ELECTRICITY METERS (ELE/14)
A. J. Gibbons, B.Sc.Tech. (27.10.36)
L. B. S. Golds (12.1.50)
G. F. Shotter (28.2.29)

TECHNICAL SUB-COMMITTEE ON DOMESTIC IMMERSION HEATERS AND THERMOSTATS (ELE/15/5)
E. Jacobi (5.3.53)

SUB-COMMITTEE ON NON-IGNITABLE AND SELF-EXTINGUISHING BOARDS FOR ELECTRICAL PURPOSES (ELE/16/13)
Appointment pending

TECHNICAL COMMITTEE ON OVERHEAD TRANSMISSION LINES MATERIAL (ELE/17)
Appointment pending

SUB-COMMITTEE ON PORCELAIN INSULATORS FOR OVERHEAD LINES (ELE/17/3)
P. K. Davis (11.5.39)
H. Willott Taylor (11.5.39)

SUB-COMMITTEE ON INSULATOR AND CONDUCTOR FITTINGS (ELE/17/7)
W. J. Nicholls, B.Sc. (6.1.55)

TECHNICAL COMMITTEE ON RAILWAY SIGNALLING APPARATUS (ELE/22)
E. G. Brentnall, M.Eng. (19.6.52)

TECHNICAL COMMITTEE ON TRAMWAY POLES (ELE/24)
T. S. Pick, B.Sc.(Eng.) (3.2.49)

TECHNICAL COMMITTEE ON RAILWAY SIGNALLING SYMBOLS (ELE/25)
Major L. H. Peter, M.C., A.F.C. (15.9.49)

* Appointed for liaison with the Wiring Regulations Committee.

TECHNICAL COMMITTEE ON ELECTRIC FANS (ELE/28)
A. S. Carr, B.Sc. (5.11.53)

TECHNICAL COMMITTEE ON RADIO INTERFERENCE SUPPRESSION (ELE/32)
G. O. Watson (22.6.44) (Representing the Ship Electrical Equipment Committee)
The Secretary of The Institution (or his deputy)

PANEL ON ABATEMENT OF INTERFERENCE AT HIGHER FREQUENCIES (ELE/32/–/1)
N. R. Bligh, B.Sc.(Eng.) (7.1.54)

SUB-COMMITTEE ON RADIO INTERFERENCE FROM TROLLEYBUSES AND TRAMCARS (ELE/32/3)
Col. Sir A. Stanley Angwin, K.B.E., D.S.O., M.C., T.D., D.Sc.(Eng.) (4.11.48)
The Secretary of The Institution (or his deputy)

SUB-COMMITTEE ON RECEIVING EQUIPMENT (ELE/32/5)
N. R. Bligh, B.Sc.(Eng.) (14.5.53)
The Secretary of the Institution (or his deputy)

SUB-COMMITTEE ON MARINE INSTALLATIONS (ELE/32/6)
Major B. Binyon, O.B.E., M.A. (8.8.39)
Sir Archibald J. Gill, B.Sc.(Eng.) (6.11.47)
G. O. Watson (8.8.39)

TECHNICAL COMMITTEE ON ELECTRIC CLOCKS (ELE/35)
Appointment pending

TECHNICAL COMMITTEE ON SAFETY REQUIREMENTS (ELE/38)
*J. Eccles, C.B.E., B.Sc. (26.2.47)
*H. W. Grimmitt (12.5.49)
*Forbes Jackson (10.4.47)

SUB-COMMITTEE ON PORTABLE ELECTRIC TOOLS (ELE/38/6)
F. H. Mann (6.3.52)

SUB-COMMITTEE ON SAFETY REQUIREMENTS FOR DOMESTIC ELECTRIC WASHING MACHINES (ELE/38/8)
H. W. Swann (20.5.54)

SUB-COMMITTEE ON ELECTRIC HAIR DRYERS (ELE/38/9)
H. W. Swann, O.B.E.

SUB-COMMITTEE ON ELECTRIC DRY SHAVERS (ELE/38/10)
H. W. Swann, O.B.E.

TECHNICAL COMMITTEE ON TERMINAL MARKINGS (ELE/41)
*E. J. Sutton (3.11.49)

TECHNICAL COMMITTEE ON EARTHING CLAMPS (ELE/45)
*H. W. Grimmitt (12.1.50)

TECHNICAL COMMITTEE ON CAPACITORS (ELE/46)
*P. R. Coursey, B.Sc.(Eng.) (3.12.53)
R. C. G. Williams, Ph.D., B.Sc.(Eng.) (21.4.49)

SUB-COMMITTEE ON CAPACITORS (ELE/46/3)
*P. R. Coursey, B.Sc.(Eng.) (3.12.53)

SUB-COMMITTEE ON LOW-VOLTAGE TRANSFORMERS (ELE/51/1)
A. J. L. Whittenham (16.9.54)

TECHNICAL COMMITTEE ON INTRINSICALLY SAFE APPARATUS (ELE/54)
C. D. Wilkinson (5.2.53)

TECHNICAL COMMITTEE ON CONSUMER SUPPLY CONTROL UNITS (ELE/57)
J. W. J. Townley, C.B.E. (20.6.46)

TECHNICAL COMMITTEE ON INSTRUMENT TRANSFORMERS (ELE/59)
G. F. Shotter (22.2.34)

TECHNICAL COMMITTEE ON POWER RATING OF INDUSTRIAL R.F. HEATING EQUIPMENT (ELE/66)
L. Carter Ludbrook, B.Eng. (13.5.48)

TECHNICAL COMMITTEE ON ELECTRIC LAMPS AND LAMPHOLDERS (AIRCRAFT) (ACE/5)
A. K. Clyde (6.12.51)

TECHNICAL COMMITTEE ON HIGH-TENSION AND LOW-TENSION CABLES FOR AIRCRAFT (ACE/6)
A. N. Irens (1.3.51)

TECHNICAL COMMITTEE ON INSTRUMENTS FOR AIRCRAFT APPARATUS (ACE/30)
C. G. A. Woodford (6.12.45)

ACOUSTICS STANDARDS COMMITTEE (ACM/–)
A. J. King, D.Sc., M.Sc.Tech. (3.2.49)
T. Somerville, B.Sc. (20.5.54)

TECHNICAL COMMITTEE ON ACOUSTICAL TERMINOLOGY (ACM/1)
W. West, B.A. (21.4.49)
[Deputy: E. W. Ayers, B.Sc.(Eng.) (5.11.53)]

TECHNICAL COMMITTEE ON ARCHITECTURAL ACOUSTICS (ACM/2)
T. Somerville, B.Sc. (21.4.49)

TECHNICAL COMMITTEE ON NOISE MEASUREMENT (ACM/3)
J. S. Forrest, D.Sc., M.A. (18.9.47)

TECHNICAL COMMITTEE ON AUDIOMETERS (ACM/4)
J. S. Forrest, D.Sc., M.A. (18.9.47)

TECHNICAL COMMITTEE ON ELECTRO-ACOUSTIC TRANSDUCERS (ACM/8)
T. Somerville, B.Sc. (16.9.48)

TECHNICAL COMMITTEE ON ELECTRIC FENCES (AGE/1)
H. W. Grimmitt (16.9.43)

TECHNICAL COMMITTEE ON UNDER-FLOOR DUCT SYSTEMS (B/43)
*E. J. Sutton (12.5.49)
Further appointment pending

SUB-COMMITTEE ON NON-METALLIC UNDER-FLOOR DUCT SYSTEMS (B/43/2)
Appointment pending

TECHNICAL COMMITTEE ON METER SPACE (B/65)
J. W. J. Townley, C.B.E. (22.6.44)

SUB-COMMITTEE ON ELECTRICAL METER SPACE (B/65/1)
J. W. J. Townley, C.B.E. (22.6.44)

SUB-COMMITTEE ON ELECTROPLATED COATINGS OF SILVER FOR INDUSTRIAL PURPOSES (CHE/18/9)
D. O. Walter (1.4.54)

TECHNICAL COMMITTEE ON VITREOUS ENAMELS (CHE/22)
E. Jacobi (14.9.44)

TECHNICAL COMMITTEE FOR BOILER WATER TESTS (CHE/37)
W. Wilde, B.Sc.(Eng.) (4.3.43)

SUB-COMMITTEE ON STAGE ELECTRICAL EQUIPMENT (CME/4/7)
*C. E. Mills (6.12.51)

COLLIERY REQUISITES INDUSTRY STANDARDS COMMITTEE (CRE/–)
P. N. Wyke, B.Sc. (10.1.52)

TECHNICAL COMMITTEE FOR REVISION OF STANDARD SPECIFICATIONS RELATING TO HOT-WATER TANKS AND CYLINDERS (HIB/7)
E. Jacobi (6.11.52)

SUB-COMMITTEE ON GALVANIZED MILD STEEL HOT-WATER TANKS (HIB/7/4)
E. Jacobi (6.11.52)

DRAFTING PANEL ON COPPER INDIRECT CYLINDERS (HIB/7/4/1)
E. Jacobi (6.11.52)

DRAFTING PANEL ON GALVANIZED MILD STEEL INDIRECT CYLINDERS (HIB/7/4/2)
E. Jacobi (6.11.52)

INSTRUMENTS INDUSTRY STANDARDS COMMITTEE (INE/–)
Lt.-Col. W. L. Beck, T.D. (15.1.48)
The Chairman of the Measurements Section (*ex officio*)

SUB-COMMITTEE ON GLOSSARY OF TERMS USED IN AUTOMATIC CONTROL SYSTEMS (INE/1/1)
Prof. K. A. Hayes, B.Sc.(Eng.) (6.11.47)

PANEL ON AUTOMATIC REGULATORS (INE/1/1/4)
Prof. K. A. Hayes, B.Sc.(Eng.) (9.4.53)

PANEL ON GRAPHICAL SYMBOLS FOR THE COMPONENTS OF SERVO-MECHANISMS (INE/1/2/2)
Prof. K. A. Hayes, B.Sc.(Eng.) (24.6.54)

TECHNICAL COMMITTEE ON TEMPERATURE MEASUREMENT (INE/4)
H. A. Thomas, D.Sc. (30.3.50)

TECHNICAL COMMITTEE ON PRESSURE GAUGES (INE/6)
G. A. V. Sowter, Ph.D., B.Sc.(Eng.) (19.6.52)

TECHNICAL COMMITTEE ON REVOLUTION INDICATORS AND RECORDERS (INE/8)
W. Bamford, B.Sc.(Eng.) (1.3.51)

SUB-COMMITTEE ON ELECTRICAL ASPECTS OF REVOLUTION INDICATORS AND RECORDERS (INE/8/2)
W. Bamford, B.Sc.(Eng.) (17.5.51)

TECHNICAL COMMITTEE ON JEWELS AND PIVOTS FOR INSTRUMENTS (INE/11)
G. F. Shotter (19.1.39)
Further appointment pending

ILLUMINATION INDUSTRY STANDARDS COMMITTEE (LGE/–)
Prof. H. Cotton, M.B.E., D.Sc. (23.6.48)
C. W. M. Phillips (2.12.48)
H. R. Ruff, B.Sc.(Eng.) (1.4.48)
J. W. T. Walsh, O.B.E., D.Sc., M.A. (8.11.51)
G. T. Winch (24.6.54)
The Secretary of The Institution (or his deputy)

TECHNICAL COMMITTEE ON PORTABLE PHOTOMETERS (LGE/1)
G. F. Freeman, M.Sc.(Eng.) (15.5.52)
Further appointment pending

* Appointed for liaison with the Wiring Regulations Committee.

TECHNICAL COMMITTEE ON ELECTRIC LAMPS (LGE/6)
*N. Sizer, M.B.E., M.C. (23.6.49)
G. T. Winch (4.2.54)

SUB-COMMITTEE ON DISCHARGE LAMPS (LGE/6/6)
*N. Sizer, M.B.E., M.C. (23.6.49)
G. T. Winch (4.2.54)

SUB-COMMITTEE ON AUXILIARIES (LGE/6/7)
*N. Sizer, M.B.E., M.C. (23.6.49)

TECHNICAL COMMITTEE ON PHOTOMETRIC INTEGRATORS (LGE/7)
G. F. Freeman, M.Sc.(Eng.) (15.5.52)
Further appointment pending

TECHNICAL COMMITTEE ON ELECTRIC SIGNS (LGE/11)
Capt. C. Higgins, O.B.E., B.Sc.(Eng.) (4.3.48)
W. R. Stevens, B.Sc. (4.11.48)
*A. J. L. Whittenham (4.12.47)

SUB-COMMITTEE ON ELECTRICAL EQUIPMENT OF MACHINE TOOLS (MEE/6/20)
E. J. Sutton (1.4.54)

TECHNICAL COMMITTEE ON PIPE FLANGES (MEE/11)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEEE ON STEAM FLANGES (MEE/11/1)
F. Shakeshaft, O.B.E. (16.9.48)

TECHNICAL COMMITTEE ON ENGINE TESTING FITTINGS (MEE/13)
F. Shakeshaft, O.B.E. (16.9.48)

TECHNICAL COMMITTEE ON PUMP TESTS (MEE/29)
H. R. Ogle (6.1.55)

TECHNICAL COMMITTEE ON LAND BOILERS (MEE/34)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON WATER-TUBE BOILERS (MEE/34/2)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON FITTINGS FOR LAND BOILERS (MEE/34/6)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON ACCESSORIES FOR LAND BOILERS (MEE/34/7)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON BOILER AND SUPERHEATER TUBES (MEE/34/9)
F. Shakeshaft, O.B.E. (16.9.48)

SUB-COMMITTEE ON ELECTRODE BOILERS (MEE/34/12)
H. E. Baker, B.A. (6.11.47)

TECHNICAL COMMITTEE ON COMPRESSORS, EXHAUSTERS AND FANS (MEE/39)
Prof. R. O. Kapp, B.Sc. (25.6.53)

SUB-COMMITTEE ON FANS FOR GENERAL PURPOSES (MEE/39/4)
Prof. R. O. Kapp, B.Sc. (25.6.53)

SUB-COMMITTEE ON MINE FANS (MEE/39/5)
P. N. Wyke, B.Sc. (25.6.53)

TECHNICAL COMMITTEE ON METHODS OF TEST FOR DUST EXTRACTION PLANT (MEE/48)
C. L. Blackburn, B.A. (5.9.34)

TECHNICAL COMMITTEE ON LIFTS, HOISTS AND ESCALATORS (MEE/49)
L. J. Gooch (1.3.45)

TECHNICAL COMMITTEE ON GRAPHICAL SYMBOLS FOR GENERAL ENGINEERING (MEE/88)
A. T. Dover (1.3.45)
The Secretary of The Institution (or his deputy)

TECHNICAL COMMITTEE ON B.S. CLASSIFICATION SCHEME OF PLANT, EQUIPMENT AND TOOLS (MEE/100)
L. H. A. Carr, M.Sc.Tech. (16.1.47)

TECHNICAL COMMITTEE ON PIPELINES, CABLES AND CONDUITS (MEE/104)
E. Jacobi (23.6.48)

TECHNICAL COMMITTEE ON SAFETY COLOUR CODE (MEE/107)
F. H. Mann (14.5.53)

TECHNICAL COMMITTEE ON INTERNAL COMBUSTION ENGINES (MEE/123)
G. O. Watson (16.1.47)
Further appointment pending

TECHNICAL COMMITTEE ON HYDRAULIC TURBINES (MEE/125)
J. E. Calverley (12.5.49)

TECHNICAL COMMITTEE ON TERMINOLOGY AND SYMBOLS FOR INDUSTRIAL WORK STUDY (MEE/132)
H. L. Weare (4.12.52)

SUB-COMMITTEE ON LEAD AND LEAD ALLOYS FOR CABLE SHEATHING (NFE/22/3)
C. E. Mills (23.6.49)

DOCUMENTATION STANDARDS COMMITTEE (OC/20)
B. M. Crowther, M.A., Ph.D. (19.6.47)
The Secretary of The Institution (or his deputy)

LOCAL AUTHORITIES STANDARDS ADVISORY COMMITTEE (ENGINEERING) (OC/23)
R. W. Mountain, B.Sc.(Eng.) (5.4.51)

TECHNICAL COMMITTEE ON THERMO-SETTING MOULDINGS (PLC/18)
C. E. Mills (24.6.54)

TECHNICAL COMMITTEE ON SAFETY BELTS (PSM/5)
Appointment pending

TECHNICAL COMMITTEE ON CONDUCTIVE RUBBER (RUC/2)
H. K. Cameron, B.Sc., Ph.D. (3.11.49)

TECHNICAL COMMITTEE ON RUBBER BELTING (RUC/16)
Appointment pending

TECHNICAL COMMITTEE ON RUBBER FLOORING (RUC/33)
H. W. Swann, O.B.E. (4.11.54)

TECHNICAL COMMITTEE ON MANUFACTURERS' TRADE AND TECHNICAL LITERATURE (S/14)
Lieut.-Col. C. A. Grover, T.D. (5.11.53)

TECHNICAL COMMITTEE ON NOMENCLATURE AND DEFINITIONS FOR SOLID FUEL BURNING APPLIANCES (SFE/1)
J. I. Bernard, B.Sc.Tech. (3.3.49)

TECHNICAL COMMITTEE ON THERMAL INSULATING MATERIAL (SFE/14)
J. I. Bernard, B.Sc.Tech. (22.6.44)

PANEL ON THERMAL INSULATING MATERIALS FOR CENTRAL HEATING AND HOT WATER SUPPLY INSTALLATIONS FOR HOUSES OF A FLOOR AREA NOT GREATER THAN 1 000 SQUARE FEET (SFE/14/1/2)
J. I. Bernard, B.Sc.Tech. (22.6.44)

TECHNICAL COMMITTEE ON BRITISH STANDARD METHODS FOR THE SAMPLING AND ANALYSIS OF FLUE GASES INCLUDING INDICATING AND/OR RECORDING INSTRUMENTS (SFE/17)
C. L. Blackburn, B.A. (20.9.45)

TECHNICAL COMMITTEE ON METHODS FOR TESTING ATMOSPHERIC POLLUTION (INCLUDING INSTRUMENTS) (SFE/21)
R. W. Griffin, B.Sc.(Eng.) (9.5.46)

TECHNICAL COMMITTEE ON AIR HEATER BATTERIES (SFE/23)
F. Shakeshaft, O.B.E. (16.9.48)

TECHNICAL COMMITTEE ON COAL (SFE/45)
J. D. Peattie, B.Sc. (15.1.48)

TELECOMMUNICATIONS INDUSTRY STANDARDS COMMITTEE (TLE/–)
R. E. Robinson (13.9.51)
C. E. Strong, O.B.E., B.A.I. (13.9.51)
Chairman of the Radio Section (*ex officio*).

TECHNICAL COMMITTEE ON TERMINOLOGY AND SYMBOLS FOR TELECOMMUNICATION (TLE/1)
E. C. Cherry, D.Sc. (5.2.53)
Secretary of The Institution (or his deputy) (5.2.53)

SUB-COMMITTEE ON NOMENCLATURE AND LETTER SYMBOLS FOR TELECOMMUNICATION (TLE/1/1)
R. C. G. Williams, Ph.D., B.Sc.(Eng.) (14.5.53)
The Secretary of The Institution (or his deputy)

SUB-COMMITTEE ON GRAPHICAL SYMBOLS FOR TELECOMMUNICATION (TLE/1/2)
L. S. Crutch, B.Sc.(Eng.) (14.5.53)
The Secretary of The Institution (or his deputy)

TECHNICAL COMMITTEE ON RADIO (INCLUDING TELEVISION) RECEIVERS (TLE/2)
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SUB-COMMITTEE ON PERFORMANCE OF RADIO RECEIVERS (TLE/2/1)
B. G. Pressey, Ph.D., M.Sc.(Eng.) (15.5.52)

SUB-COMMITTEE ON MAINS SUPPLY APPARATUS FOR RADIO RECEIVERS, ETC. (TLE/2/2)
*H. G. Gamble (17.3.47)
*Forbes Jackson (17.3.47)
E. M. Lee, B.Sc. (6.3.47)

TECHNICAL COMMITTEE ON RADIO (INCLUDING TELEVISION) TRANSMITTERS (TLE/3)
V. J. Cooper, B.Sc.(Eng.) (5.2.53)

SUB-COMMITTEE ON RADIO (INCLUDING TELEVISION) TRANSMITTER PERFORMANCE (TLE/3/1)
V. J. Cooper, B.Sc.(Eng.) (5.2.53)

SUB-COMMITTEE ON RADIO (INCLUDING TELEVISION) TRANSMITTER SAFETY REQUIREMENTS (TLE/3/2)
Sir Archibald Gill, B.Sc.(Eng.) (5.2.53)

* Appointed for liaison with the Wiring Regulations Committee.

TECHNICAL COMMITTEE ON COMPONENTS FOR TELECOMMUNICATION EQUIPMENT (TLE/4)
G. J. McDonald, B.Sc.(Eng.) (4.3.54)

SUB-COMMITTEE ON CONNECTORS FOR RADIO AND TELEPHONE CIRCUITS (TLE/4/2)
J. E. E. Collyer (6.3.47)
Prof. J. Greig, M.Sc., Ph.D. (5.12.46)

SUB-COMMITTEE ON VIBRATION MACHINES FOR AIRCRAFT RADIO (TLE/8/2)
K. A. F. Frost, B.Sc.(Eng.) (30.3.50)

PANEL ON SHOCK AND VIBRATION TERMINOLOGY (TELECOMMUNICATION) (TLE/8/2/1)
G. P. Parker (3.12.53)

SUB-COMMITTEE ON AIRCRAFT RADIO EQUIPMENT (TLE/9)
K. A. Frost, B.Sc.(Eng.) (30.3.50)
C. E. Strong, O.B.E., B.A.I. (8.2.46)

SUB-COMMITTEE ON AIRCRAFT RADIO EQUIPMENT CONNECTORS (TLE/9/1)
G. P. Parker (5.11.53)

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Col. J. Reading, M.B.E., B.Sc.(Eng.) (6.12.51)
The Secretary of The Institution (or his deputy)

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The Secretary of The Institution (or his deputy)

TECHNICAL COMMITTEE ON TERMINOLOGY, LETTER SYMBOLS AND ABBREVIATIONS (USM/2)
A. T. Dover (4.12.52)
The Secretary of The Institution (or his deputy)

SUB-COMMITTEE ON ELECTRICAL ENGINEERING LETTER SYMBOLS AND ABBREVIATIONS (USM/2/1)
G. E. Williams, B.Sc.(Eng.) (16.9.54)

COMMITTEE ON STATISTICAL METHODS (STANDARDIZATION AND SPECIFICATIONS) (USM/3)
Sir W. Gordon Radley, C.B.E., Ph.D.(Eng.) (3.4.52)
The Secretary of The Institution (or his deputy)

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A. E. Villiers, M.A. (17.9.53)

SUB-COMMITTEE ON WELDING PLANT AND EQUIPMENT (WEE/6)
H. G. Taylor, D.Sc.(Eng.) (26.4.45)
A. E. Villiers, M.A. (18.9.47)

COMMITTEE ON RESISTANCE WELDING EQUIPMENT (WEE/26)
H. G. Taylor, D.Sc.(Eng.) (4.2.54)

BURY TECHNICAL COLLEGE, ENGINEERING ADVISORY COMMITTEE
J. Mills (8.11.51)

CANNOCK CHASE MINING AND TECHNICAL COLLEGE—ENGINEERING ADVISORY COMMITTEE
J. Ashmore (13.9.51)

CARDIFF COLLEGE OF TECHNOLOGY AND COMMERCE—ADVISORY SUB-COMMITTEE FOR THE DEPARTMENT OF APPLIED PHYSICS AND ELECTRICAL ENGINEERING
J. Vaughan Harries (4.2.54)

CAROLINE HASLETT TRUST COMMITTEE
J. W. Leach (17.5.51)

CITY AND GUILDS OF LONDON INSTITUTE

ADVISORY COMMITTEE ON ELECTRICAL ENGINEERING PRACTICE
L. H. A. Carr, M.Sc.Tech. (13.5.48)

ADVISORY COMMITTEE ON ELECTRICAL INSTALLATION WORK
L. H. A. Carr, M.Sc.Tech. (13.5.48)

ADVISORY COMMITTEE ON ELECTRODEPOSITION OF METALS
H. K. Cameron, B.Sc., Ph.D. (18.9.47)

ADVISORY COMMITTEE ON ILLUMINATING ENGINEERING
G. F. Freeman, M.Sc.(Eng.) (16.9.54)

ADVISORY COMMITTEE ON INSTRUMENT MAINTENANCE
S. Whitehead, D.Sc., M.A. (12.1.50)

ADVISORY COMMITTEE ON MECHANICAL ENGINEERING DESIGN
H. West (4.3.48)

ADVISORY COMMITTEE ON MACHINE SHOP ENGINEERING
L. H. A. Carr, M.Sc.Tech. (4.11.48)

ADVISORY COMMITTEE FOR MECHANICAL ENGINEERING INSPECTION
Lieut.-Commander R. B. Fairthorne, R.N.(Retd.) (1.4.54)

ADVISORY COMMITTEE ON MINING EDUCATION
B. L. Metcalf, B.Sc.(Eng.) (9.10.52)

ADVISORY COMMITTEE ON ELECTRIC-ARC AND OXY-ACETYLENE WELDING
A. C. Davies, B.Sc. (18.9.47)

ADVISORY COMMITTEE FOR RADIO AMATEURS' EXAMINATION
R. C. G. Williams, Ph.D., B.Sc.(Eng.) (23.6.48)

ADVISORY COMMITTEE ON TELECOMMUNICATIONS ENGINEERING
T. E. Goldup (7.3.46)

ADVISORY COMMITTEE FOR RADIO SERVICE WORK
R. C. G. Williams, Ph.D., B.Sc.(Eng.) (23.6.48)

ADVISORY COMMITTEE ON LABORATORY TECHNICIANS' WORK
M. W. Humphrey Davies, M.Sc. (15.9.49)

EDUCATION POLICY COMMITTEE
M. W. Humphrey Davies, M.Sc. (7.12.50)

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A. Nemet, Dr.Ing. (6.11.52)

ADVISORY COMMITTEE ON INSTRUMENT MANUFACTURE
J. E. Richardson, Ph.D., B.Eng. (9.10.52)

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C. E. Mills	Fire Offices Committee.
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R. H. Coates, B.Sc.(Eng.)	Institution of Mechanical Engineers.
F. H. Mann	Ministry of Labour and National Service.
H. W. Grimmitt	Ministry of Fuel and Power.
S. N. Edwards	Ministry of Supply.
P. McKearney	Ministry of Works.
P. N. Wyke, B.Sc.	National Coal Board.
Appointment pending	North of Scotland Hydro-Electric Board.
Col. J. Reading, M.B.E., B.Sc. (Eng.).	Post Office.
E. M. Lee, B.Sc.	Radio Industry Council.
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Chairman: E. M. Lee, B.Sc.

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* *Deputy:* V. A. Woodliffe.

CODE DRAFTING COMMITTEE ON STREET LIGHTING

Chairman: J. W. T. Walsh, O.B.E., D.Sc., M.A.

Institution nominees:
Appointment pending.
The Chairman of the Utilization Section (*ex officio*).

DRAFTING SUB-COMMITTEE
Chairman: J. W. T. Walsh, O.B.E., D.Sc., M.A.

CODE DRAFTING COMMITTEE ON SUPPLY, METERING AND CONSUMERS' CONTROLS

Chairman: J. W. T. Townley, C.B.E.

Institution nominees:
S. G. Christian.
C. W. Hughes, B.Sc.
Forbes Jackson.
T. M. H. Stubbs.
W. H. Walton.
A. H. Young.

CODE DRAFTING COMMITTEE ON TELECOMMUNICATION

Chairman: H. G. S. Peck, B.Sc.(Eng.).

Institution nominees:
W. H. Brooks.
S. L. Helman.
C. King.

JOINT I.MECH.E./I.E.E. PANEL ON FIRE ALARMS
Chairman: W. H. Tuckey, O.B.E.

Institution nominees:
C. King.
F. H. Mann.
H. G. S. Peck, B.Sc.(Eng.).

CODE DRAFTING COMMITTEE ON WIRING SYSTEMS

Chairman: H. J. Cash.

Institution nominees:
†C. J. Armstrong.
J. Flood.
Forbes Jackson.
M. McKearney.
F. H. Mann.
*C. E. Mills.
A. V. Milton.
W. A. Smith.
T. M. H. Stubbs.
K. H. Tuson.

* *Deputy:* V. A. Woodliffe.
† *Deputy:* F. J. Bassett.

CODES OF PRACTICE COMMITTEE FOR MECHANICAL ENGINEERING (MECP/–)

Institution nominee: F. H. Mann (24.6.54).

CODES OF PRACTICE COMMITTEE FOR BUILDINGS (BLCP/–)

Institution nominee: Forbes Jackson (29.4.54).

CODE DRAFTING COMMITTEE ON LIFTS, HOISTS AND ESCALATORS

(formerly convened by The Institution of Mechanical Engineers)
Institution nominee: H. W. Fulcher (2.12.43).

CODE DRAFTING COMMITTEE ON MECHANICAL REFRIGERATION

(formerly convened by The Institution of Mechanical Engineers)
Institution nominee: K. J. R. Cocke, B.Sc.(Eng.) (4.3.48).

CODE DRAFTING COMMITTEE ON OPTICAL PROJECTION EQUIPMENT FOR SCHOOLS
(formerly convened by the Illuminating Engineering Society)
Institution nominee: V. M. Roberts, B.Sc. (8.8.48).

CODE DRAFTING COMMITTEE FOR INDEPENDENT FIRES
(formerly convened by the Royal Institute of British Architects)
Institution nominee: J. I. Bernard, B.Sc.Tech. (16.1.47).

Forthcoming Events *at savoy place*

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E	EDUCATION DISCUSSION CIRCLE	O	ORDINARY MEETING
Ex	EXTRA MEETING	R	RADIO SECTION
I	INFORMAL MEETING	S	SUPPLY SECTION
M	MEASUREMENTS SECTION	U	UTILIZATION SECTION

1955 — After each paper that has now been published is added the month that its synopsis appeared in the *Journal*.

FEBRUARY

17 *Thursday*

P. J. BHATT, B.SC.(ENG.)
"An Introduction to the Study of Servo Mechanisms"* — **U**

E. J. DAVIES, B.SC.
"The Development of 50 c/s Traction in France"*

G. GASCOIGNE
"Electricity applied to Oil Production"*

21 *Monday*

COMDR. C. G. FORSBERG, R.N., *and* G. G. MACNEICE, B.SC. — **R**
Informal Lecture on "The Recent Search for and Salvage of the Comet Aircraft near Elba"‡

23 *Wednesday*

Å. RUSCK — **S**
Lecture on "High-Voltage Transmission Developments in Sweden," followed by a film on "The Gotland High-Voltage D.C. Transmission Scheme"*

24 *Thursday*

Annual Dinner (at Grosvenor House, Park Lane, W.1, at 7 for 7.30 p.m.)

MARCH

1 *Tuesday*

PROFESSOR F. BRAILSFORD, PH.D., WH.SC., *and* C. G. BRADSHAW, B.ENG. — **M**
"Iron Losses at High Magnetic Flux Densities in Electrical Sheet Metals" (Paper No. 1794)§ *Synopsis:* February, 1955

C. D. MEE, B.SC., PH.D., *and* R. STREET, M.SC., PH.D.
"An Improved Precision Permeameter" (Paper No. 1746) (Published in the *Proceedings*, Part II, December, 1954)

2 *Wednesday*

E. N. BRAMLEY, M.SC. — **R**
"Some Aspects of the Rapid Directional Fluctuations of Short Radio Waves reflected at the Ionosphere" (Paper No. 1713)‖ *Synopsis:* August, 1954

E. N. BRAMLEY, M.SC.
"Some Comparative Directional Measurements on Short Radio Waves over Different Transmission Paths" (Paper No. 1716)‖ *Synopsis:* September, 1954

W. C. BAIN, M.A., B.SC., PH.D.
"On the Rapidity of Fluctuations in Continuous-Wave Radio Bearings at High Frequencies" (Paper No. 1715)‖ *Synopsis:* October, 1954

K. C. BOWEN, B.A.
"Sources of Error in U-Adcock High-Frequency Direction-Finding" (Paper No. 1810)§ *Synopsis:* February, 1955

3 *Thursday*

G. L. E. METZ — **O**
"The Electrical Engineering Industry in the Post-War Economy—II" (Paper No. 1795)§ *Synopsis:* February, 1955

7 *Monday*

C. M. COCK will open a discussion on "What is the Future of the Steam Locomotive?"* — **I**

9 *Wednesday*

P. E. AXON, O.B.E., M.SC., PH.D., C. L. S. GILFORD, M.SC., *and* D. E. L. SHORTER, B.SC.(ENG.) — **R**
"Artificial Reverberation" (Paper No. 1796)§

* No advance information will be available.
‡ A synopsis will be available in advance.
§ This paper will be published not later than 10 days before the date of reading.
‖ This paper has now been published (see page 107).

MARCH

10	*Thursday*	F. W. ROBERTS, B.SC.(ENG.) "The Electrical Equipment of the Toronto Subway Cars" (Paper No. 1754)‖ *Synopsis:* October, 1954	Ex
15	*Tuesday*	J. C. WEST, B.SC., PH.D., *and* J. L. DOUCE, M.SC. "The Mechanism of Sub-harmonic Generation in a Feedback System" (Paper No. 1693)‖ *Synopsis:* July, 1954	M
		J. C. WEST, B.SC., PH.D., *and* P. N. NIKIFORUK, B.SC. "The Transient Behaviour of Remote-Position-Control Systems with a Hard-Spring Non-Linear Characteristic" (Paper No. 1728)‖ *Synopsis:* October, 1954	
16	*Wednesday*	R. T. RUSHALL *and* J. S. SIMONS, B.SC.(ENG.) "An Examination of High-Voltage D.C. Testing applied to Large Stator Windings" (Paper No. 1771)‖ *Synopsis:* January, 1955	S
17	*Thursday*	A. O. JOHNSON, B.SC.TECH., *and* N. F. MARSH, M.A. "The Standardization of Retail Electricity Tariffs" (Paper No. 1798)§ *Synopsis:* February, 1955	U and S
21	*Monday*	R. O. JENKINS, PH.D., will open a discussion on "Materials for Valves"†	R
22	*Tuesday*	T. SIKLOS, DIPL.ING., will open a discussion on "High-Voltage Equipment in Colleges"* (at 6 p.m., tea at 5.30 p.m.)	E
22	*Tuesday*	Section Dinner-Dance (at the Café Royal at 7 for 7.30 p.m.)	S
23	*Wednesday*	J. CHRISTIE, H. LEYBURN, B.SC.(ENG.), *and* J. F. BIRD, M.C., T.D., B.SC. "Proving the Performance of Circuit-Breakers, with particular reference to those of Large Breaking Capacity" (Paper No. 1707)‖ *Synopsis:* August, 1954	S
		J. CHRISTIE, H. LEYBURN, B.SC.(ENG.), *and* R. W. FENN, M.ENG. "A New Testing Station for High-Power Circuit-Breakers" (Paper No. 1736)‖ *Synopsis:* December, 1954	
30	*Wednesday*	Radio and Measurements Sections Dinner-Dance (at the Café Royal at 7 for 7.30 p.m.)	R and M
31	*Thursday*	E. W. GOLDING, M.SC.TECH. "Electrical Energy from the Wind" (Paper No. 1727)‖ *Synopsis:* December, 1954 See also page 70	O

APRIL

5	*Tuesday*	D. M. MACKAY, B.SC., PH.D. "High-Speed Electronic-Analogue Computing Techniques" (Paper No. 1738)‖ *Synopsis:* October, 1954	M and R
14	*Thursday*	W. HOLTTUM, M.ENG. "The Installation of Metal-Sheathed Cables on Spaced Supports" (Paper No. 1814)§	U
18	*Monday*	H. W. SWANN, O.B.E., will open a discussion on "Domestic Circuits and Protection Devices"*	I
19	*Tuesday*	R. DAVIS, M.SC., will open a discussion on "The Measurement of Impulse Voltages and Currents with special reference to the Testing of Surge Diverters"†	M
20	*Wednesday*	G. H. METSON, M.C., PH.D., M.SC., B.SC.(ENG.) "A Study of the Long-Term Emission Behaviour of an Oxide-Cathode Valve" (Paper No. 1790)§	R
21	*Thursday*	W. SHOCKLEY, B.SC., PH.D. The Forty-Sixth Kelvin Lecture on "Transistor Physics"*	O
22	*Friday*	K. R. STURLEY, PH.D., B.SC., will open a discussion on "Technical Training in North-West Germany"* (at 6 p.m., tea at 5.30 p.m.)	E
27	*Wednesday*	G. F. PEIRSON, A. H. POLLARD, B.SC., *and* N. CARE "Automatic Circuit Reclosers" (Paper No. 1717)‖ *Synopsis:* December, 1954	S
28	*Thursday*	H. I. ANDREWS, M.SC., PH.D. "The Adhesion of Electric Locomotives" (Paper No. 1797)§	Ex
30	*Saturday*	Section Visit to Lime Grove Television Studios and White City Television Centre	S

* No advance information will be available.
† An abstract of the introduction will be available in advance.
§ This paper will be published not later than 10 days before the date of reading.
‖ This paper has now been published (see page 107).

District Meetings

Arrangements for the remainder of the session for District meetings other than those held in the area of a Local Centre.

1955

HATFIELD (At the Hatfield Technical College, at 7 p.m. Tea at 5.30 p.m.)

MARCH **31** *Thursday*

A. D. J. RATCLIFFE, M.SC.(ENG.), B.SC.

"Speed Control of A.C. Motors for Hoist Motions; the Dynabrake and Minispeed Systems"*

IPSWICH (At the Crown and Anchor Hotel, at 6.30 p.m. Tea at 6 p.m.)

MARCH **7** *Monday*

L. J. DAVIES, M.A., B.SC.

Lecture on "Research in the Electrical Manufacturing Industry"*

MAIDSTONE (At the Wig and Gown Hotel, at 7.30 p.m.)

MARCH **7** *Monday*

P. M. HOLLINGSWORTH, M.ENG., *and* P. A. RAINE

"Aluminium-Sheathed Cables" [*Proceedings I.E.E.*, Paper No. 1638 S, April, 1954 (**101**, II, p. 603)]

APRIL **4** *Monday*

Annual General Meeting and Informal Discussion

NORWICH (At the Assembly House, at 7.30 p.m.)

MARCH **10** *Thursday*

D. HICKS, M.SC.

Lecture on "Fuel Supplies of the Future"*

OXFORD (At the Demonstration Room, Southern Electricity Board, 37 George Street, at 7 p.m.)

MARCH **9** *Wednesday*

E. P. FAIRBAIRN, M.C., B.SC.

"Some Aspects of the Design of V.H.F. Mobile Radio Systems" [*Proceedings I.E.E.*, Paper No. 1522 R, July, 1953 (**101**, III, p. 53)]

READING (At the George Hotel at 7.15 p.m.)

MARCH **14** *Monday*

Open Forum

* No advance information will be available.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 1st January, 1955.

ELECTIONS

Associate Members

ALEXANDER, Eric William George.
BAXTER, John Seymour Raymond, B.Sc.(Eng.).
BERRY, John Edward.
BLAIR, Gabriel Matthew, Lieut.-Col.
BLOODWORTH, Reginald Stanley.
BOYLE, Richard Courtenay, Captain, R.N., D.S.C.
BRYKCZYNSKI, Roman Antoni, Dipl.Ing.
BURTON, John Marcus, B.Sc.Tech.
CHAKRABARTI, Radharaman.
CLAYTON, Cyril Edwin.
COBB, Edwyn Harland Wolstenholme, Major General, C.B., C.B.E.
de LACY, Eamonn Michael Francis, B.E.
ENGINEER, Homi Merwan, B.Eng.
GEORGE, Norman Stanley.
GHOSE, Rabindra Nath, M.Sc.(Eng.).
HAMMERSLEY, Reginald Mark Hughes.
HODGES, Gordon Francis.
JOHNSON, Walter Albert.
JONES, Denis Stanley Webb.
JONES, Owen Gilbody.
KARNEY, William Philip.
LONG, Robert Rivett, B.E.E.
MITCHELL, William Frederick.
PARSONS, Walter Cyril.
RIBCHESTER, Eric, B.Sc.
RISTIC, Dimitrije, Dipl.Ing.
ROCKALL, Ernest Albert.
SCHOTANUS A STERINGA IDZERDA, Henrikus Hanso, Dipl.Ing.
SCRINE, Richard Claude.
SHAW, Francis Graham.
SPALL, George William.
STOCK, Alfred Charles.
VOWELS, Rex Eugene, M.E.
WATTS, Colin.
WHISKARD, John, B.Sc.(Eng.).
WHITE, Bernard Joseph.
WILKINSON, Gordon John.
WOOLLARD, Maurice Ethelbert.

Associates

BAYETTO, Ronald Attillio.
BRODEY, Stanley Baxter.
DOIG, Neil McDonald.
HUDDLESTON, Geoffrey Frederick.

Associates (contd.)

JONES, Cyril.
LIDGEY, Harry.
PARNELL, Walter James.
PEACH, Edward Clifford.
PEACH, Frank.
RICHARDSON, William Donald.
RITCHIE, Roy.
SAGOO, Harbhajan Singh.
SHIPTON, John.
SMETHURST, Harold.

Graduates

ABBOTT, Colin Reginald Elverston.
ADDERLEY, Kenneth John, B.Sc.(Eng.).
ALEXANDER, Francis Spencer.
ALLVEY, Colin Henry William, B.Sc.(Eng.).
ARNOTT, Herbert John.
ASLETT, Raymond Gwyther.
BAILEY, Charles Henry John.
BAKER, Alan Shirley.
BAKER, Derek David George.
BALLINGER, Albert Leslie.
BARNARD, Frederick John.
BARTON Stanley.
BEDDOES, John Michael, B.Sc.(Eng.).
BEECH, Herbert Alfred.
BENNETT, Reginald Frank Charles.
BHATWADEKAR, Sharad Shriniwas.
BINDON, Clifford Malcolm Hampton.
BISSELL, Reginald Arthur.
BOLWELL, Keith Urwin, B.Sc.(Eng.).
BORRETT, Leonard Robert.
BOYD, James Maurice.
BROOKS, Kenneth Norman.
BROWN, Ian Bryson.
BROWN, John.
BUCHAN, Andrew.
BULL, David John.
BURTON, Harry.
CALTON, Ernest.
CARTER, Norman Joseph.
CHANNON, Dennis Edward.
CHARLES, Brian Victor William.
CLARE, Ronald Peter.
CLAY, Colin Andrew Edlin.
CLAYDON, Geoffrey Alan
CLIFFORD, Dudley Stuart, B.Sc.(Eng.), Ph.D.(Eng.).
COLWELL, Roy Ernest.
CRESSWELL, Edward Ernest.
CULLING, Peter Leonard.
CURTIS, Barry John, B.E.E.
DAGNALL, Leonard.
DAVID, David Abdullah, B.Sc.(Eng.).
DEAN, Robert George.
DENNIS, Peter Rodney.
DRYDEN, Leonard.
DUK, Wladyslaw.
DURBER, Frederick Roy.
EAST, Francis Glanville.
EDE, Dennis Ronald.
EMSLEY, Thomas Forrest.
ETCHELLS, Alfred Latham.
ETCHELLS, Eric Harry.

Graduates (contd.)

EVANS, Derek.
EVANS, Trevor Llewelyn.
FAIREY, Raymond Vivian.
FINE, Roger Clive, B.A.
FROW, Brian Kenneth, B.Sc.(Eng.).
FULLER, Richard Ernest.
GOODFELLOW, Edwin Alexander.
GOSLETT, Patrick Gwyn.
GREGORY, Billy.
GRUNDY, Ewart Sidney.
HALLIDAY, Jack.
HANKIN, Robert William.
HARRIS, Basil Vivian.
HART, John Richard.
HAYWARD, Peter Harold.
HEAD, Michael John.
HENRICK, Ernest John.
HENRY, Laurence.
HEWITT, Eric John Robert, M.A.
HIBBARD, Rex Kenneth.
HICKS, Douglas George.
HIEROWSKI, Stanislaw Roman, B.Sc.
HINTON, Richard Brian.
HOLLINGTON, Horace Basil.
HOTZ, Basil Ralph, B.Sc.(Eng.).
HUGHES, Leonard Victor.
IRVING, Allan.
JANSSON, Leonard Eric.
JOHNSON, Robert Cyril, B.Sc.(Eng.).
JOYCE, John Stein, B.E.
JUREK, Stefan Franciszek Leopold, B.Sc.(Eng.).
KAMINSKI, Henryk.
KEARNS, Frederick Denis.
KIRK, Albert.
LANE, Peter John.
LIPPA, Kurt, B.Sc.(Eng.).
LISTER, Michael Stanley John.
LORD, Jack Allan.
LOWE, Richard.
McKINLEY, Robert William, B.Sc.
McNEILLIS, Francis.
MALACZYNSKI, Zbigniew Aleksander.
MANNERS, Ernest.
MARSTON, Ian.
MASTERMAN, Victor Frank George.
MICHAEL, Kenneth.
MINNITT, Frank.
MOYNIHAN, Timothy Valentine Rae.
MYALL, Gordon Alan.
NICHOLSON, George Duncan, B.Sc. (Eng.).
OLIVA, Emmanuel Nicholas.
OSBORNE, Leslie Edward.
PADDOCK, Frederick John.
PAINTON, Philip Edward.
PARROTT, Denis.
PEARSON, Benjamin.
PENDLETON, Eric.
PERRY, Frederick Charles.
PIGOTT, Francis Michael, B.E., B.Sc.Tech.
PILLING, Roy Munro.
PRICE, Charles Arthur.
PRINGLE, James.
PURDY, John.
RAESIDE, James Stewart.
REECE, George Herbert.
REEVES, Douglas Edward Allen, B.E.
RICHARDS, Arthur Edwin.
RICHARDSON, Anthony Jack, B.Sc.
ROBERTSON, George.
ROSTRON, Harry.
ROTHWELL, John.
SENGUPTA, Ajoy Kumar, B.Sc. (Eng.).
SLADE, Ronald Charles.
SMITH, Cedric Edward.
SMITH, Derek Bertram.
SNELL, Edwin Harry.
SPEEDY, Charles Brian, Ph.D., B.E.
SPENCER, Rodolph George.
STEVENS, William Roy.
STIRRUP, Thomas Boardman.
TAVENER, Leonard Charles.
TEBAY, James.
THOMAS, Charles Darrell.
THOMPSON, Ronald.
TOMLINSON, Ernest.
TOOP, Robert Henry.
TRANTER, John Norman.
TREANOR, George Vincent.
TRENDELL, Edward George, B.Sc. (Eng.).
TROLLOPE, Robert Basil.
TUNNICLIFFE, William Stephen, B.Sc.(Eng.).
WAHAB, Mohamed Hassanbin Abdul, B.Sc.(Eng.).
WALDOCK, Eric Charles.
WALTER, Norman Archibald.
WATKINS, Christopher Michael James, B.Sc.(Eng.).
WATSON, Herbert Douglas.
WATSON-JONES, Bernard, B.Sc.
WATT, James McKenzie, B.Sc.
WELLS, George William, B.Sc.(Eng.).
WHITING, Philip.
WHITTICK, Walter Kenneth.
WILSON-DUTTON, Leslie Cyril.
WINDLE, Donald James.
WOLSEY, William Ernest.
WOODMORE, Malcolm James.
WORDEN, James.

Students

ADAMS, Brian.
ANDERSON, James Laurence Wallace.
ASHWORTH, Michael William.
ATHERTON, Derek Percy.
BAILEY, Philip.
BAILEY, Richard Grenville.
BARTLETT, Kenneth Ivor.
BEHENNA, Norman Wilfred.
BHASKARAN, Gopalakrishnier.
BICKFORD, Terence John.
BLYTHE, James William.
BOOTH, Alfred Ernest.
BROOKMAN, Alan Kenneth, B.Sc.
BROUNCKER, Anthony Charles John.
BROWN, Michael.
BRYANT, Geoffrey.
BUTTON, Kenneth Victor.
CAMPBELL, James Martin.
CHANDY, Kallukkattu Varughese.
CHAUDHARI, Vinayak Krishnaji.
CHINASING, Sean Christopher.
CLARKE, George David.
CLARKE, Raymond William.
COOK, Harold Benjamin.
CORLESS, Norman Fergie.
CREAK, Richard Adrian.
DAVIES, Norman Clifford.
DAWSON, Roger Neil.
DE LOM, Paul William.
DE NEUT, Brian Anthony.
DINENAGE, John Brian.
DIX, Dennis Lee.
DUNCAN, Alexander.
ELKINGTON, Christopher.
ELLIOTT, John.
EVANS, Harold.
FAIRS, Christopher Lancelot.
FALLON, Noel Francis, B.E.
FROOME, David Sweetland.
FROST, Christopher John.
FULLWOOD, Kenneth John.
GALE, William Melville, B.Sc.
GANE, Alan Ernest.
GILBERT, Gerald.
GOLDING, Michael Ernest.
GORTON, Ronald, B.Sc.
GUNBY, Richard.
GUPTA, Krishna Avtar.
HAINES, Michael Barry.
HALL, Thomas David.
HARKNESS, John Alan.
HARP, Arthur Braddon.
HARVEY, Robert Graeme.
HIPKIN, Richard Charles.
HOLLELY, Roger William.
HOSING, Pralhad Damodar.
HOSKINS, Peter John.
HULLET T, Allan Victor.

Students (contd.)

HULLEY, Lancelot Norman.
HUMPHREYS, Brian Clifford.
HUMPHREYS, John Henry.
IGIEHON, Henry Imarhiagbe.
ILES, Gordon David.
ISLAM, Qazi Motaharul.
JACKSON, Peter Alan.
JARVIS, Peter.
JAYASINHE, Bandula Wijesundere.
JESUTHASAN, Moses Daniel.
JOHNSON, David Brook.
JOHNSON, Dennis.
JOHNSON, Eric.
JOHNSON, Harold Brian.
JOLLY, Michael Eliot.
JULKA, Baldev Raj.
KANNAN, Vasudevan.
KENKARE, Arvind Shantaram.
KENNARD, David Edward.
KHANNA, Beant Lal.
KULASEGARAM, Kumarasamy.
LAMKIN, Geoffrey Antony.
LATHAM, Richard Patrick Gwyn.
LEE, Ronald Harold Frederick.
LINDSAY, Thomas.
LUM, Yun Foo.
McDONALD, Anthony Charles.
McDONALD, James Alexander.
McKERNAN, Thomas Alexander.
MAIN, Peter George.
MANOHARAN, Ratnasabapathy.
MAY, Jack Richard, B.Sc.
METHUEN, Robert Alexander Holt.
MIDDLETON, Terence Henry.
MILBURN, Peter Anthony.
MONTGOMERY, Peter Murdo.
NEWEY, David Alan.
NG, Cheong Kiong.
NICHOLSON, James Duncan.
O'NEILL, Barry Hyde.
PAISLEY, David.
PATEL, Suryakant Trikamlal.
PATERSON, Frank.
PAYNE, Gladstone Olumide.
PEARSON, Alan Eric.
PEET, John Dennis.
PERERA, Karannagoda Kankanamalage Yasaratna Wijayasundara.
PHILLIPS, John.
PHILLIPS, Vivian Jones.
POCOCK, Rowland Francis.
POWELL, John Eric.
POWNEY, John, B.Sc.
PRESCOTT, Albert James.
QADRI, Syed Nizamuddin.
RAGI, Abbas Ali.
REID, Anthony Alexander.
ROSE, John Foster.
RUSSELL, Colin Peter.
SANDFORD, Bryan Moile.
SAUNDERS, John Lancelot.
SAYER, George Edwin John.
SCOTT, Edward John.
SELVARAJAH, Ponnampalam.
SHEEN, Patrick Anthony David.
SHELDON, John Graham.
SHILSTONE, Bruce Miles.
SHORTALL, Robert Dominic.
SIMPSON, Michael Augustine Gregory.
SINGH, Harmeet.
SINGH, Ram.
SKEVINGTON, Roland John.
SMITH, John Alfred.
SMITH, John William, B.Sc.
SMITH, Raymond Graham.
SMITH, Roland Antony.
SOMASUNDERAM, Thanikasalamoorthy.
SOOD, Ajudhia Nath.
SPARKMAN, Maurice Hugh.
SPELDEWINDE, Francis Garvin Courtenay.
SPELLER, Edgar Charles.
SPINKS, David.
STANIFORTH, James Alan.
STEELE, Raymond.
STEPHENS, Jeremy Hewitt.
SUBBARATNAM, Sinnaswamiayar.
SWAINSTON, Christopher Mortimer.
SYKES, David John.
SYMONS, Owen Charles.
THOMPSON, Ian Forbes.
TOMLINSON, Brian Arrandale.
TONG, Jonathan Felix.
TYLER, Herbert.
VAN SCHOOR, Martin Edward Sedgwick, B.Sc.
WALKER, Edwin James.
WALKER, Richard John.
WANKLING, James Leonard.
WELCH, Graham Peter.
WHITWORTH, Michael Conroy.
WILKINSON, Billy.
WINTERS, Rex Henry.
WOOD, John Irwin.

TRANSFERS

Associate Member to Member

BARNARD, Rodney George, Wing Comdr., R.A.F.
BATTY, Frank Sudbury, M.Eng.
BELLAIRS, Guy ffarrington, Lieut.-Col., R. Signals, B.Sc.(Eng.).
BENNETT, William Moore, Lieut.-Comdr., R.N.V.R.
BOYCE, John William, B.Sc.(Eng.).
BUXTON, Simeon, Lieut.-Col.
CARTER, Eric Briscall.
CHAPPELL, Raymond George.
CLEWLEY, John Thomas.
COLE, Gordon Leslie.
CROWE, Henry Eyre.
DESHMUKH, Bhagwant Vyankatesh, M.Sc.Tech.
ENTWISTLE, Herbert, B.Sc.(Eng.).
GRANT, Kenneth Oliver.
GRIERSON, Richard Alan.
HAINE, Michael Edward, M.Sc.
HALSTEAD, Frederic John.
HEFTMAN, Tadeusz Stefan, Dipl.Ing.
HILL, John Henry Richard.
HINTON, Cyril Herbert, B.Sc.Tech.
KENYON, Alec Hindle.
KOUYOUMDJIAN, Kerop Kaloust, B.Sc.
MARTIN, Charles Albert, B.Sc.(Eng.).
MULLINS, Arthur Robert, B.A.
NARAYANAMURTHY, Parvathi Vaidyanatha A.
NICOL, James Campbell Barr, B.Sc.
PIKE, Allan Robert, B.Sc.(Eng.).
RATCLIFFE, James Corlett, B.Sc. Tech.
REES, Horace Edward.
RISCOE, Vilhelm Schjelderup, B.Sc. (Eng.).
ROWE, William Roy.
SCOTT, Edward Chalmers, B.Sc (Eng.).
SHEKHDAR, Nariman Maneckji.
TAYLOR, Ernest, B.Sc.
TYRRELL, Leslie Osborne.
WILLIAMS, Alfred Henry.

Associate to Associate Member

BARLOW, Stuart Lansdale Monteagle.
DAWES, Osborne Kenneth.
DRIVER, Eric Ronald.
HOLT, Joseph Barrington.
LAMONBY, Joseph.
PENROSE, Harold Ernest.
SHAW, Sydney.
WHITE, Owen Frederick John, Major, R.E.

Graduate to Associate Member

ABBOTT, Hugh Hector.
ADAMS, Peter David, B.Sc.(Eng.).
ADLAM, John Harry, B.A.
ALLEN, William.
ALMOND, John Wilson, B.Sc.
APPLEBY, Arthur.
ARKLESS, John Chisholm, B.Sc.
AUTON, Geoffrey.
BAILEY, Arthur Deasy.
BALDWIN, William Edward Bernard.
BALLARD, Dennis William.
BARTON, Thomas Herbert, B.Eng., Ph.D.
BATES, John Joseph.
BEARHAM, David Ramsay, B.Sc. (Eng.).
BEESLEY, William.
BELSEY, Stuart Urquhart.
BERRY, Douglas George, B.Sc.
BILBIE, Alan Walter.
BIRD, Gerald.
BLACK, George Clark.
BLACKLIN, Joseph Alfred.
BODE, Arthur James.
BOTT, Alan.
BOWKETT, Harry Ewart.
BOYETT, Edgar William.
BRACEWELL, George Marshall.
BROMFIELD, Alec Desmond.
BROOKS, Norman Colston, B.Sc. (Eng.).
BUMSTEAD, Maurice Charles.
BURGETT, John Warneford, B.Sc. (Eng.).
BUTLER, John.
CALDWELL, John Eric, B.Sc.(Eng.).
CAMLIN, Thomas.
CARDANI, Armand, B.Sc.
CARMICHAEL, James.
CARTER, Cecil Thomas, B.Sc.(Eng.).
CHAN Khee Pok, B.Sc.(Eng.).
CHAPMAN, Arthur Newton, B.Eng.
CIBOROWSKI, Boleslaw Czeslaw.
CONRADI, Cedric Schofield.
CONWAY, Reginald.
CRACKNELL, George Leslie, B.Sc. (Eng.).
CRISPIN, John Arnold, B.Sc.Tech.
DALE, Kenneth Malcolm, B.Sc.(Eng.).
DASTUR, Jehangir Bomanji, B.Sc. (Eng.).
DATTA, Budh Dev.
DEANS, Robert Pearson.
DODD, Charles Aaron.
EARL, John Alexander, B.Sc.(Eng.).
EAVES, Phillip Sydney Kett, B.Sc. (Eng.).
EDWARDS, Kenneth.
EMMERSON, Thomas, Ph.D., B.Sc.
EVANS, Leonard Samuel.
FAIRBROTHER, Eric.
FAIRHEAD, Arthur William.
FOX, Geoffrey Charles.
FROUD, Michael.
FULTON, Hugh.
GASSON, Laurie.
GAY, John Anderson, B.Sc.
GREGSON, Leslie, B.Sc.
GROVES, Reginald Frederick, B.Sc. (Eng.).
GUNTER, John Watkin, Major.
HALL, John Claude.
HALL, Ronald George.
HARDY, John Wheeler, B.Sc.(Eng.).
HARMER, John David, B.Sc.
HARRISON, William Monk, B.Sc. Tech.
HARVEY, Gordon Webster, B.Sc. (Eng.).
HARVISON, Ronald Eric, B.Sc.
HATTON, Arthur Heathcote, B.Sc.
HAYWARD, George William.
HINCHLIFFE, John Derek Smithies, B.Sc.
HITCHCOCK, Raymond John, B.A.
HOLLOWAY, Douglas Rowland, M.Sc.
HOMEWOOD, Norman Kenneth.
HOPKINS, Dennis Alan, B.Sc.
HUTCHINSON, Derek Lancaster, B.Sc.(Eng.).
HUTCHISON, Douglas Stuart, B.E.E.
JAMES, Antony Bracher.
JOHNSTON, Hugh Philip.
JONES, Harold Alan.
KATESMARK, Ronald Gordon, B.Sc.(Eng.).
KENSHOLE, Gordon Edward, B.Sc. (Eng.).
KLOTZ, Richard Henry.
KNOWLES, Henry Lofthouse.
LEE, Kenneth Francis William.
LEMMON, Donald William, B.Sc. Tech.
LILBURN, Alistair James.
LINES, Raymond John, B.Sc.(Eng.).
LOCKYER, Keith Gerald, B.Sc.
McCAIG, Donald.
McGRATH, David.
McGUCKIN, Charles Vincent.
McLELLAN, Ronald Charles.
MAHER, Geoffrey Michael, B.E.
MAKIN, Alan Walter, B.Sc.(Eng.), Ph.D.
MARSHALL, Percival Lionel.
MASKREY, Gordon John.
MILLER, Andi Alfred, B.Sc.(Eng.).
MILLER, Michael George, Captain, R.E.M.E., B.Sc.(Eng.).
MILLS, Clive Henry George, B.Sc. (Eng.).
MINTY, Alan.
MOORHOUSE, Brian, B.Sc.(Eng.), Ph.D.
MOSLEY, Desmond Edgar.
MOSS, George, B.Sc.(Eng.).
MOULLIN, Victor Edward.
NASH, George Lister.
NELIS, Michael Thomas.
NORMAN, Kenneth George.
OUGHTON, Albert Gordon.
PANTON, Peter, B.A.
PARR, Richard Geoffrey, B.Sc.(Eng.).
PATERSON, John Drummond.
PEARCE, Noel, B.Sc.
PHELOPS, Marcus, B.Sc.(Eng.).
PHILLIPS, Christopher James.
PHILLIPS, Geoffrey John, M.A., Ph.D.
PITCHER, Wilfred Meredith.
PLATTS, John Raymond, B.Sc.(Eng.).
POHL, Walter John, M.Sc.
POLAK, David, B.Sc.Tech.
PRICE, William George Courtenay, B.Sc.(Eng.).
RAVEN, John Moelwyn, B.Sc.(Eng.).
READ, Peter Haines, Major, R.E.M.E., B.Sc.
REEVES, Eric Alwyn.
REYNOLDS, Walter Adams.
RICHARDSON, Arnold Keith William.
RIPPENGAL, John Edward.
ROBB, Derek Arundel, B.Sc.(Eng.).
ROBINSON, Alexander.
ROSS, Frank Alexander.
ROWSON, Donald Walter, Wing Comdr., R.A.F., B.Sc.
SEILLY, Basil William.
SHAND, Frederick Gordon.
SHARROCK, Thomas.
SHAW, Bernard Elliott, B.Sc.(Eng.).
SHEPHERD, George Ronald.
SHEPSTONE, Kenneth Alfred Laude.
SHIP, Victor Douglas.
SHORE, Raymond, B.Sc.
SIMPSON, Robert Alan, B.Sc.
SLEE, George Edward.
SMITH, Alfred Edward.
SMITH, James Embleton.
SMITH, Stanley Thompson.
STARTIN, James Valentine, B.Sc.
STEVENS, Richard Sidney, B.Sc. (Eng.).
STEVENSON, Donald Gilfillan, B.Sc. (Eng.).
STOREY, David John, M.A.
TALKS, Raymond, M.A.
TAYLOR, Maurice George Arthur.
THOMAS, Alan Geoffrey, B.Sc.(Eng.).
THOMAS, Tudor.
THOMPSON, Arthur Edwin.
TOMLINSON, Terence Bernard, Ph.D., B.Sc.
TUCKER, Brian Arthur.
VERRALL, Roswell Victor, B.E.
VIGURS, Joseph Arthur.
WATSON, George Peter.
WEEDEN, Kenneth Norman.
WHITE, Eric Oliver.
WHITE, Peter Lowther, B.Sc.
WHYMAN, Philip Henry Warner, B.Sc.(Eng.).
WOOD, Derrick Lewis, Sqdn. Ldr., R.A.F., B.Sc.
YOUNG, Frank Edgar, M.A.

Graduate to Associate Member (contd.)

Student to Associate Member

BACK, Ronald Eric George.
GOODSHIP, Geoffrey.
RAY, Andrew Ivor Abdy.

Student to Graduate

ALLISON-BEER, Martin.
ARMSTRONG, Samuel.
AUTY, Eric.
AYLES, Jack.
BAMPTON, Norman Frederic.
BARRACLOUGH, Robert.
BEUKERS, John Michael, B.Sc. (Eng.).
BEWSHER, Neil Richard, Sub-Lieut. (L), R.N.V.R., B.Sc.(Eng.).
BLACKHALL, Kenneth Albert John.
BLAKEMORE, John Frederick.
BOAL, George Alexander.
BOOTH, John Halswell, B.Sc.(Eng.).
BOWN, Norris.
BOYDLE, Jack.
BRAYNIS, Manfred Emmanuel.
BRAZENELL, Clement William.
BRISTOR, Arthur Alfred.
BROWN, Lawrence.
BROWNSEY, Neville John, B.Sc.
BURNETT, William.
BURROWS, John William Alan, B.Sc.(Eng.).
BURTT, Roger Brian, M.Sc.Tech.
CARDEN, Herbert Thomas.
CARPENTER, Basil George.
CARR, James.
CARTER, James.
CLAMP, Geoffrey Masters.
CLARKE, Max Percival Preston, B.Sc.(Eng.).
CLOSE, Dennis.
COCKLE, Anthony.
CREASEY, Dennis Raymond.
CURWEN, Kenneth Joseph.
DAHL, Eyolf, B.Sc.
DANIEL, Frederick Leonard Upton, B.Sc.(Eng.).
DANIELS, Ronald Charles.
DARUVALA, Dinshaw Jehangir, B.A.
DAVIS, Lewis Stanley.
DICKSON, Malcolm Robert, B.Sc. (Eng.).
DUDLEY, Dennis William.
DUNDERDALE, Herbert, B.Sc.Tech.
EATON, Ronald.
EDMEADES, Dennis George John.
EDMONDS, Peter Richard.
EDWARDS, James Albert.
EVANS, Meurig, B.Sc.(Eng.).
FARROW, Miss Jennifer Louise, B.Sc.(Eng.).
FLEMING, Michael.
FLETCHER, Charles Gordon.
FORD, Raymond William.
GIBSON, Michael Raymond.
GOLDBERG, Henry.
GOODIER, Alan Vivian, B.Sc.(Eng.)
GRANDFIELD, George Geoffrey.
GROLLET, Dudley Francis.
GROVE, Michael Fayle, B.A.
HAAS, Zbigniew Antoni, B.Sc.(Eng.).
HADJIALEXIOU, Aristoteles D., Dipl.Ing.
HAKKAK, Ezra Meir.
HALL, Robert.
HARDIE, Peter Geoffrey Sealey.
HELLIWELL, Kenneth, B.Sc.Tech.
HODGE, Brian Herbert, B.Sc.
HOLDER, Martin Albion Charles.
HOSKING, Derek James Edward.
HOUSE, Arthur Trevor.
JACKSON, Michael Oldfield.
JACOBS, Robert Leonard.
JONES, Bryan Peter.
JOWERS, Jeffrey Donald.
KARDOOSH, George Saliba, B.Sc. (Eng.).
KEECH, Norman George.
KLEIN, Robert.
LEWIS, Henry Rae.
LI, Yuan Lu.
LISTER, Donald John.
LOCK, Frederick Collett.
LOWE, Patrick Graham, B.A.
LUSCOMBE, Kenneth Edward.
McCANN, Keith, B.Sc.(Eng.).
McCARTHY, Peter George.
MACDONALD, Ronald Robert.
MacDOUGALL, John.
MACFARLANE, John Stewart, B.Sc.
MARTIN, Alan Paul, B.Sc.(Eng.).
MATHEWS, Victor Alexander, B.Sc. (Eng.).
MATHUR, Raghbeer, B.Sc.(Eng.).
MBIWAN, Ebaichuo Agbotoko, B.Sc.
MERLO, David, B.Sc.(Eng.).
MICHAELIS, Philip Siegfried, B.Sc. (Eng.).
MILNE, Alfred James Graham, B.Sc.
MORRIS, Francis.
MYATT, Leslie James, B.Sc.(Eng.).
O'BRIEN, Anthony, B.Sc.Tech.
OLIVANT, William Malcolm.
PAGE, Peter John Abbott, B.E.
PATERSON, James Hugh, B.Sc.(Eng.).
PENNINGTON, John Michael, B.A.
PIPER, John Henry, B.Sc.(Eng.).
PORDAGE, Derek Charles.
RAE, Alan Peter, B.Sc.(Eng.).
RIGBY, Richard Henry, B.Sc.Tech.
SALISBURY, Eric Philip.
SAUNDERS, John Hammond.
SAYWELL, Arthur.
SCHINDLER, Peter Bellamy.
SHEPHERD, Lewis Archibald.
SINGARAJAH, Christopille, B.Sc. (Eng.).
STEAD, Ernest.
STEELE, David Gordon Dixon.
STONE, Christopher David.
STRONG, James, B.Sc.
STUTZ, Peter Ralph, B.Sc.(Eng.).
SUNDERLAND, John Lewis.
SZATKOWSKI, Franciszek.
THOMAS, Peter George.
THOMPSON, Anthony St. Maur, B.Sc.(Eng.).
TOZER, David Francis, B.Sc.(Eng.).
TRIGG, Richard John Paul.
TUCKEY, Cyril.
VINCENT, Gordon Stanley.
VINCENT, Owen Thomas.
WARING, Leslie Phillip.
WARREN, David Kingsley, B.Sc. (Eng.).
WARREN, Trevor Reginald.
WARSHAW, Nigel Claude.
WEBSTER, Reginald Trevor.
WEEDY, Birron Matthew, B.Sc.(Eng.).
WESTMORE, John Reginald.
WILDE, Peter, B.Sc.(Eng.).
WOOD, John Keith, M.Sc.

The following elections and transfers approved by the Council are effective from the 6th January, 1955.

ELECTIONS

Graduates

AKED, Charles Kenneth.
ASHFORTH, John Vincent, B.A.
BAILEY, Noel Scholefield, B.A.
BARWICK, Robert Gordon.
BASSETT, Albert.
BEER, Wilfred Charles, B.Sc.(Eng.).
BINDON, Francis John Leopold.
BONTHRONE, Alex.
BRADING, Alan Thomas.
BUSFIELD, Clifford Arthur.
CAMPBELL, Douglas Barrett.
CARAMONDANIS, Stavros Yerasimou, B.Sc.
CHESTERS, Henry Robert, B.Eng.
CHETTLEBURGH, Kenneth George, B.Sc.(Eng.).
CHOWDHURY, Santi Prosad.
CLARK, James Oliver, B.Eng.
COCKBURN, Keith.
COOK, John Henry.
COVILL, Thomas Charles.
CURRER, Gordon Wilfred.
CURRIE, Harry.
DAVIDSON, Christopher Eden.
DAVIES, Philip Hywel, Pilot Officer, R.A.F.
DUFF, George Alexander.
EASTWOOD, Joe Patrick.
EVANS, Thomas Edward.
FORDHAM, Reginald Charles.
FOSTER, Cyril Walter.
GILBURT, Cyril Ernest.
GILLARD, Jim Henry.
GODFREY, Brian John Francis.
GORTON, Alan Vincent, B.Sc.Tech.
GOYAL, Radhey Shiam.
GRAYSTONE, Roy Stuart.
GUNN, William Arthur.
HANSON, John Edward.
HARDY, Paul.
HARVEY, Walter George, B.Sc.(Eng.).
HEBDITCH, Geoffrey Francis William.
HILDRETH, Jeffrey Herbert.
HILL, Dennis Walter, M.Sc.
HODGSON, Peter, B.Sc.
HOWARTH, Denis Sherwood.
HUMPHRIES, Wesley.
JONES, Noel Edward.
KIBART, Peter Wallace.
KLINGER, Yehuda, M.Sc.
KNOX, Keith Anthony Thomas, B.Sc.(Eng.).
LANE, John William, B.Sc.(Eng.).
LING, Adrian John.
LORD, John Henry, B.Sc.(Eng.).
McCORMACK, David William.
MACLEAN, Hector Macdonald.
MARSH, William Henry.
MAYO, Peter.
MEADS, Edward Frederick.
METCALF, Anthony James.
MIDDLETON, Leslie Stuart Gordon.
MITCHELL, Frank.
MOORE, Bernard William.
MOSS, Brian.
NEWTON, Derek John.
OWEN, John Michael, B.Sc.
PICKFORD, Harry.
PLATNICK, David, B.A.Sc.
POMFRETT, Cyril, B.Eng.
POVEY, John Arthur.
PUGH, Raymond Herbert.
RAMSAY, William Alistair.
RAZZELL, Tony Maurice.
RIDLEY, Colin.
RILEY, Barry Milton, B.Sc.
RODGER, Ridley.
RUSSELL, Frederick Philip.
SIMPSON, Raymond.
SINGER, Geoffrey William, B.A.
SMITH, Eric Roland.
SMITH, Percy Charles.
SPURGIN, Dennis Allen.
STENSON, Bernard.
STEPHENSON, George William.
SWINN, Graham Roland, B.Sc.
THOMPSON, Geoffrey.
THOMPSON, George Alexander, B.Sc.(Eng.).
THOMSON, John Craig.
TOOMBS, Jack, Captain, R.E.M.E.
TRIVEDI, Navnitray Ranchhodlal, B.Sc.Tech.
VERNON, Hubert Sidney, Captain, R.E.M.E.
WALSH, Norman.
WARD, John Howard.
WELLS, Thomas.
WEMBRIDGE, George Parry.
WHITE, John Henry.
WHITEAKER, Edward John.
WILSON, David Henry, B.E.
WORMALD, Gerald Anthony.
WYER, Peter.
YATES, Cyril George.
YOUNG, Andrew.

Students

ADY, Brian Kenneth.
ALCOCK, Derrick Norman.
ALECOCK, Grahame John, B.E.
APPASWAMY, Thillaivelu.
ATKINSON, Dennis.
BAILEY, Gordon.
BAKER, Alan William.
BALL, Christopher Jefferson.
BELL, Hugh Arthur.
BHATTACHARYA, Himanshu Shekhar.
BILLINGTON, William Frank.
BIRD, Brian Michael.
BIRD, Denis Jefferson.
BLADES, Michael William, B.Sc.
BLUMENTHAL, Miss Elizabeth Ann.
BOYLE, Robert Daniel.
BRADBURY, Kenneth John.
BRUSH, Ralph John Howell.
BUNZL, Thomas Felice.
BURGESS, John Michael.
BURNELL, John.
CAMPBELL, George Murray.
CARDWELL, Thomas Cuthbert.
CARTWRIGHT, William.
CHARD, Walter Keith.
CHARLES, Peter Wilson.
COLE, David Arthur.
COLE, Jack Arthur.
CONSTANTINOU, Antis Michael.
COOPER-READE, Michael Anthony Berridge.
COURTNEY, Graham Sidney.
COUTTS, William Donald.
DAVIDSON, Angus James Sommerville.
DENTON, John.
DEVEREUX, Jeffrey Reginald.
DIGWEED, David James Alfred.
DOYLE, Patrick Joseph.
DRAPER, David Warwick.
ELLIS, Edward Lovell.
EVANS, Kenneth.
FARRELL, Daniel Richard.
FERNANDO, Kamal.
FERNANDO, Panthiyage Bertram Noel, B.Sc.(Eng.).
FEY, Derek Albert Edward, B.Sc.
FIELD, Frederick Laurence Fentiman.
FREER, Robert, B.C.E.
GAME, Peter Robert.
GASSER, James Fowler.
GEERE, Desmond Hubert.
GHOSH, Asoke Kumar.

Students (contd.)

GRACIE, John.
GREEN, David Maxwell.
GRUNDY, Gerald Francis Nicholls.
HALE, Clifford.
HARRIS, George Frederic.
HAWKINS, John.
HEALD, Leslie, B.A.
HEMMING, John Edward.
HILBIG, Maxwell John.
HINCHLIFF, Charles Arthur Keith.
HINDE, John Robertson.
HODSON, John.
HOOPER, Edmund Peter Jack.
HUGHES, Albert.
HUGHES, Brian Victor.
INGLE, Edward Arthur.
JACOBS, Allan Vivian Rollo.
JAMSHEDWALA, Nariman Nadirshaw.
JEFFERS, David Edmund.
JEFFERY, Norman.
KHALIQ, Malik Abdul.
KHAN, Mohamed Waheeduddin.
KING, Albert Ignatius Kwong Ping.
KISHORE, Prabhanjan, B.Sc.
KOZLOWSKI, Antoni.
LANGLOIS, Peter John.
LEA, Bernard James.
LEA, Michael John.
LEE, David Roland.
LEWIS, William George.
LUTO, Alan Tony.
LYNCH, Michael John, M.Sc.
LYONS, Edward.
McLACHLAN, Arthur.
McMAHON, John Philip.
McNEILL, Joseph Clement.
MINGAY, Brian Scott.
MISTRY, Dara Dhunjishaw.
MITTER, Sanjoy Kumar.
MOE, Shwe, B.Sc.
MOORE, David Henry.
MOORE, Lawrence.
MORRISON, Ian Christie.
MOULDER, George Albert Joseph.
NATARAJAN, Thiniyam Subramanya.
NAYLOR, John Antony.
NORRIS, William Tobias.
NUNN, Edward George.
OAKLEY, Keith Adrian.
OTHMAN, Akram Rashid.
OTTER, Alan John.
PANDYA, Prabodh Prabhulal.
PARK, Allan Thomas.
PRATHAPASIMHA, Hindupur Vasantharao.
QUARSHIE, Jonathan.
RAMACHANDRAN, Ravunniarath.
REES, David Burnell.
REYNOLDS, Robert Andrew.
RICHMOND, Eric Ivor.
ROBBINS, Anthony George.
ROBINSON, David.
ROSS, Alexander.
SCHAERER, Ronald Adolph.
SHEARD, Fred.
SHIPTON, Brian Talbot.
SINGH, Shri Bansh Narain.
SNELL, Peter Robert.
STARR, Richard Edwin.
STEWART, Charles McGregor.
STEWART, Robert Thomas.
STYAN, Peter Ormonde.
SUMMERTON, Donald.
THOMAS, David Gordon.
THOMPSON, Michael Hamilton.
THROP, George Malcolm.
TOWNSEND, Philip Edward.
TRUSS, William Frederick.
VISUVANATHAN, Sinnathamby, B.Sc.(Eng.).
WALLIS, Alan Douglas.
WALTERS, Lawrence Arthur.
WEBSTER, Cornelius Roy.
WHITE, Brian Leslie.
WHITE, Geoffrey.
WILSON, Ian.
WILSON, Michael Gage Farlow.
WRIGHT, Raymond Alfred.

TRANSFERS

Student to Graduate

AGGLETON, Roy Graham.
ALDRIDGE, John Beauclerk.
ANG, George, B.Sc.(Eng.).
BARTHO, Andrew Donald, B.Sc.(Eng.).
BEARDMORE, Alexander Francis, B.Sc.(Eng.).
BEVAN, Stuart Graham.
BREWSTER, John, B.Sc.(Eng.).
BRIDGES, Leonard Thomas, B.Sc.(Eng.).
BROWN, Michael Anton Cedric Salkeld.
BURT, George Alan.
BUSSELL, Roy Sydney.
CHITTENDEN, William Harry.
CLARGO, Norman George, B.Sc.(Eng.).
COLE, John Andrew.
CONWAY, John William Andrew.
CROOK, Richard Wallace.
CRUMMACK, Raymond, B.Eng.
DAVIES, Philip Frank.
DAWSON, Edmund Barry.
DILLOW, John Warren, B.Sc.(Eng.).
DOUCHE, Barrington Radcliffe.
EVERETT, David Thomas.
FERGUSON, James Archibald Hamilton, B.Sc.
GALVIN, Ronald Albert William.
GARTHWAITE, George William.
GOODWIN, Clive.
GOWANS, Ronald Basel.
GREEN, Robert James.
HAMPSHIRE, Arthur.
HARRI, John Michael.
HEDGE, Tony Alister.
HERRING, Ronald.
HILL, Bernard Thomas.
HINDLE, Elmer William Ralph.
HOLLINGS, Frederick Charles.
HOLMBOE, Christian Fredrik.
HORNE, Leslie.
HOWARD, Alan Patrick.
HOWARD, Peter James, B.Sc.(Eng.).
JONES, Elwyn.
JONES, Peter Albert, B.Sc.(Eng.).
JUNG, Herbert Ludwig, B.Sc.(Eng.).
KENDRICK, Stanley Harry.
KNIGHT, John Ormonde.
LINCOLN, Bryon John, B.Sc.Tech.
MURCH, Leslie John.
PAYNE, John Wilfrid Scott, B.Sc.(Eng.).
PERRY, Edwin Arthur.
PETERSON, Leonard Percival.
PORTER, Alan.
PRICE, Derek Alfred Charles.
RAY, Robin Edwin.
REDWOOD, Martin, B.Sc.(Eng.).
ROBERTSON, Ian Stanley, B.Sc.(Eng.).
SAGE, Ronald William.
SELLERS, Norman, B.Sc.
SINGH, Hardial.
SUTHERLAND, Christopher Stonehouse, B.Sc.
TRUEICK, William, B.Sc.
VEASEY, Thomas Patrick.
VERNON, James Harold, B.E.
WARREN, Edward Jeffery.
WATSON, Alan, B.Sc.
WICKHAM, Roger Alan, B.Sc.(Eng.).
WILLS, Joseph Noel.
WOODLEY, William Alan, B.Sc.
WRIGHT, Brian Harry, Sub. Lieut. (L), R.N.V.R.
YEOMANS, John, B.Sc.(Eng.).

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